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PETRALOGY.

A

TREATISE ON ROCKS.

BY J. PINKERTON.

VOL. II.

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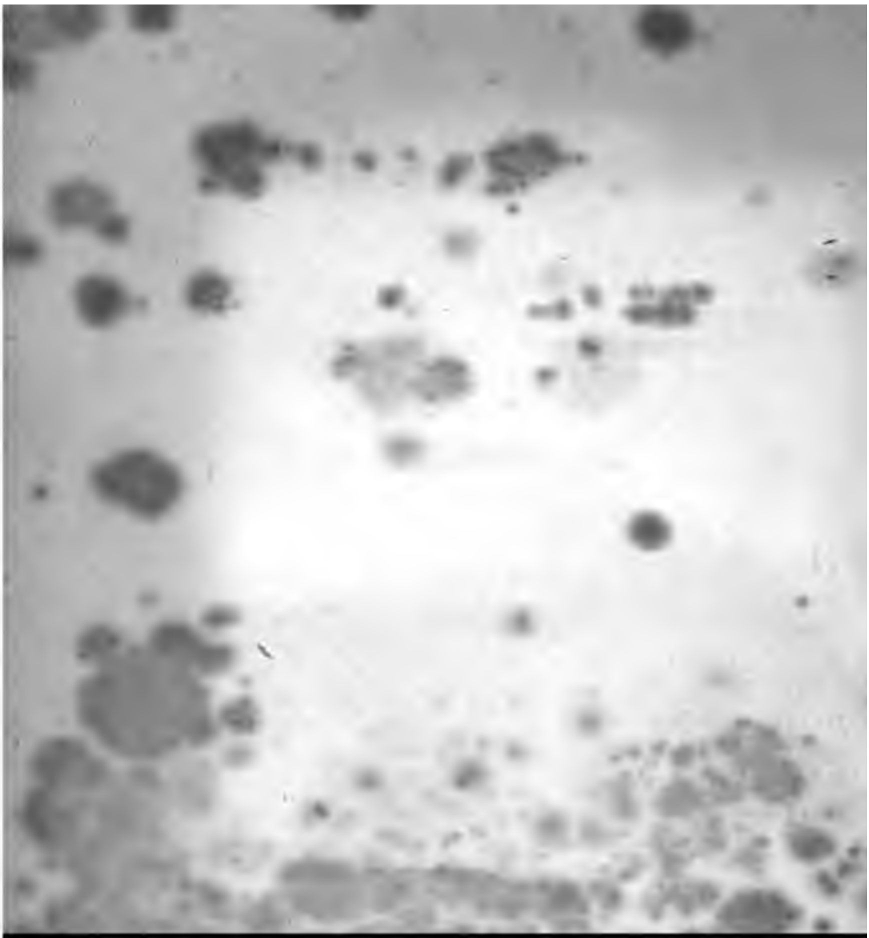

PETRALOGY.

A TREATISE ON ROCKS.

INTRODUCTION

TO THE SECOND VOLUME.

Accidental rocks.

HAVING in the former volume comprised all the Domains which may be called Substantial, as depending upon the predominant substance, under various modes of combination, it is now necessary to enter on another field, that of the Accidental Rocks, which must of course be arranged according to their various accidences*. These accidences being, so to speak, infinitely diversified, and independent of any Mode in the sense used in the former volume, and often even of Structures and Aspects, it was necessary to adopt new denominations. Even the Domains now become what might be called Dominions in the natural kingdom, as they no longer imply the preponderant or predominant substance, but grand divisions arising from natural accidences, as the Volcanic and Decomposed Rocks.

New terms.

But while the term Domain still seemed unobjectionable, it became necessary to abandon the other subdivisions, which being derived from the substances, and their qualities, could have no place here. Instead of denominations strictly arising from the very essence of the subject discussed, the subdivisions themselves became, so to speak, accidental and arbitrary. The only idea that arose was to select terms that might indicate subdivisions of the Domains, and still, if possible, preserve some relation with chemistry, upon which the whole science of mineralogy ultimately depends. In Egypt, universally known to have been the parent country of chemistry, the small provinces or districts were distinguished by an appellation which the Greeks have translated NOMES, from a word simply implying divisions. But the word may be said to have remained sacred to Egypt, not having been transferred to the provinces of any other country. This word had also the advantage of subdivisions easy to the memory, in Hyponome and Micronome, implying greater and lesser subdivisions of the Nome.

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* Pliny has *naturæ accidentia*; Cicero *accidentia* for *res attributæ*. *Accidence* is here used in contradistinction to *accident*, which, in common English, implies a moral event or incident, not an accidental circumstance in nature. Accidence is here a natural casualty, an adventitious attribute.

Nome.

Hyponome. Micronome.

Such were the reasons for the preference of this arbitrary term to any other arbitrary term; and as it cannot be too often repeated that the chief use of any system of natural history is to assist the memory, it will perhaps be difficult to find a term less objectionable; at least, though the plan has been deeply reconsidered for many years, none such has arisen to the author: but perhaps candid disquisition, and literary collision, may produce some more appropriate appellation, which he would be the first to adopt, having no view but the advancement of the science. Even in lithology and metallogy, Nomes will be found preferable to the Groups or Families of the Wernerians, denominations chiefly belonging to animated nature; and the clear metallic divisions of Thomson, Alloys, Sulphurets, Oxyds, and Salts, may well be styled Nomes; for the term being arbitrary there can be no objection to its occasional introduction even under Domains which are substantial.

Terms sometimes lax.

Above all it must not be forgotten, that in no science, except those that are mathematical, can the terms admit mathematical precision. In the other kingdoms of natural history it is well known that disputes frequently arise whether a new object form a genus, a species, or a variety. How much more vague, therefore, must be the language of mineralogy, which depends on the infinite modifications of the various substances forming the shell or crust of this vast globe? Impressed with this idea, Patrin has pronounced that the best arrangement is that which is the most lax, because pretended precision would in itself be a radical error: for nature is not regular, but free; and it becomes part of the perfection of a system to partake of that freedom. To expect, therefore, mathematical exactness, or metaphysical acuteness, in the arrangement and nomenclature of natural history, would be foreign to the very nature of the science itself; and if even the most precise and mathematical terms could be found, they would be improper in mineralogy, where the substances themselves are inaccurate, and all the divisions are mutually intermingled, and graduate into each other. In the Substantial Domains even complex rocks, as granite, &c. are equally simple with some substances regarded as homogenous; and smaragdite, for example, will present as numerous ingredients. But in the Substantial Domains the Modes are variations of the same substance, and naturally follow each other; while the Nomes are compounds wholly different in themselves, and connect detached substances in an arrangement totally distinct. In the former case the terms themselves may be regarded as definitions, which is a great advantage in any science; while the Nomes must, from the very nature of the subject, be considered as arbitrary divisions for the sake of memory. In this point of view a system may be compared to a cabinet; and if each substance can find its proper drawer and place, the object of utility and clearness are answered. But at the same time every system, even the Newtonian, has its anomalies.

Nomenclature.

In this, as in the former part, it became a chief object to increase the nomenclature, the poverty of which has long been regretted by Saussure, and other able authors. Buffon presents some useful observations on this topic. "Men have begun with giving different names to things which have appeared to them clearly distinct; and at the same time they have formed general denominations for objects which seemed to resemble each other. Among savages, and in all new languages, the names are almost always general, that is to say, vague expressions for objects of the same similitude, however distinct. An oak, a beech, a linden, a yew, a pine, a fir, will all at first be called a *tree*; then the oak, the beech, the linden, will all be called oaks, till they be distinguished from the others, which will be called pines. But particular names will only be found in an advanced state of society, after comparisons and examinations; and the number has been always increased in proportion as nature is more studied and better known; and the more it is examined and compared, the more abundant will be the proper names and peculiar denominations. But when we are now presented with general terms, that is *genera*, it is to send us back to the A B C of knowledge, and recall the darkness of the infancy of nations. Ignorance has created *genera*, science has produced, and always will produce, proper names; and we are never afraid to augment the number of particular denominations when we wish to designate different objects."

This eloquent author was, however, too inimical to systems of nomenclature on the Linnæan plan; and his observations may be considered as chiefly applicable to mineralogy, in which the arbitrary divisions have been so often confounded, as has already been explained in the general introduction to this work. The most severely scientific writer on mineralogy is Haüy, but even he has been obliged repeatedly to change the subdivisions; for in the first class he has genera, in the second only species; in the third there are two orders; in the fourth three orders, and every metal forms a genus. Nay, as already stated, he has changed the very foundation of his plan, having formally abandoned the integrant molecule, which, as he supposed, constituted the species, for the primitive form, as he confesses that he was often deceived by the integrant molecule*. This molecule was the invention of

Hauy's deviations.

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* His argument that crystals resemble the flowers of plants, as a criterion of species, is not just, the crystals being often different from the substance, quartz in limestone, barytes in granite, &c. &c.

the ingenious crystallogist Romé de Lisle; and formed the foundation of the singular production of Dolomieu on the Mineralogical Species, in which he goes so far as to assert that this species can propagate itself! This nugatory proposition seems merely to have been advanced, because he allows that without this quality no species in natural history can exist. Let it not be imagined that such observations, extorted merely by the impulse of truth, are intended to violate the respect due to those great writers in other departments of the science, which is sufficiently wide for the developement of various talents; and though the eagle requires a whole province of rocks for his immediate domain, there is in this science ample space for invention and ability, without enmity and without envy.

Volcanic rocks.

It is hoped that the nature of the several domains contained in this volume will be found to be sufficiently illustrated by the observations at the head of these divisions. One of the most important, in every point of view, is the Volcanic, an object of ludicrous neglect and contempt to the German mineralogists, whose confined ideas have been the more implicitly followed, because the Germans are the fathers of modern mineralogy. It will here be found to be treated with the details, and it is hoped with the accuracy, which the subject deserved, not only from its own importance, and contradistinction from all the other domains, but on account of the infinite contestations which have arisen on this topic among the most eminent writers in the science. Diffident, however, of his own ideas, it gave the author singular satisfaction to find them confirmed by those of the first chemist of this or any age, as may be judged by the following extract from one of our weekly journals *.

* Observer, June 2d, 1811.

Dr. Davy's observations.

"In the concluding lecture, Dr. Davy stated, that the emission of lava from volcanoes was one of the principal operations by which nature supplied the waste of rocks, and the destruction of the land noticed in his former lectures. The agency of volcanoes in the production of islands, and the increase of continents, is more extensive, than those who reside at a distance from their influence are disposed to admit. Proofs of this may be traced in the islands and shores of the Mediterranean, in the continent of America, and in Asia, and in other parts of the globe. Nearly the whole of Sicily, and the southern parts of Italy and France, offer evidence of their volcanic origin; and Rome, which has by ancient writers been proudly styled the "Eternal City," is built on the crater of an extinct volcano. The phenomena attending the eruption of volcanoes were described from Hamilton, Dolomieu, Spalanzani, and others, who had been present during the eruptions of Etna and Vesuvius.

"The convulsion of the solid ground, the lofty columns of flame, smoke, and vapour, the tremendous explosions, the torrents of rain, and the thunder and lightning, which accompany the eruption of lava, all indicate that the immediate cause is the expansion of steam and hydrogen gas, which inflames when in contact with the atmosphere. The doctrine of a central fire was unsupported by proof or analogy: did such a fire exist its effects must be felt at the surface, even if it had to pass through the most imperfect conductors of heat.

"To ascertain the cause which produced the expansion of vapour, and the other phenomena of volcanoes, we must examine the products of these august operations of Natural Chemistry. If we observe a fire at a distance, and are able to collect its products, we may thence determine the nature of the substances which have been in a state of combustion. The products of volcanoes are hydrogen gas, vapour, and lava, of which lava is a compound of the earths, the alkalies, and the oxyd of iron.—In his former lectures, Dr. Davy observed, that he had stated the discovery of the metallic nature of the earths and the alkalies, and that the metals obtained from them were in a high degree inflammable when they came in contact with water.—Dr. Davy further observed, that previous to the eruption of volcanoes, the lakes and springs in their neighbourhood were known to have suddenly disappeared; and all the volcanoes which are in activity are in the neighbourhood of the sea, or of large lakes*. Now if we admit that these earths exist under the surface, in a metallic state, the access of water to them would occasion their combustion. The oxygen would be absorbed, and an immense volume of hydrogen gas would be produced, which is always found to follow the eruption of flames. This explanation of the cause of volcanoes may be considered as a reasonable influence from the discovery of the metallic nature of the earths; and if we admit the operation of electrical agency in the globe, we shall have a cause operating by which the earths may be restored to their metallic form. Thus the process of renovation and decay will be constantly balancing each other, and nature be preserved in a state of eternal youth. The appearance of the Aurora Borealis and the Aurora Australis, render it probable that the poles are in two different states of electricity, and that a constant circulation of electric power is taking place.

"Though new land and soil may thus be formed, Dr. Davy said he was not inclined to admit that the primary and secondary rocks were thus produced. The crystals they contain are different from those ever found in lava. The experiments of Sir James Hall, which had been thought to establish the volcanic nature of basalt, he considered as defective. In basalt, hornblende and felspar are distinctly crystallised; but the fused basalt which had slowly cooled, though it had the form of basaltic prisms, did not contain hornblende or felspar in distinct crystals.

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* The Andes are from 80 to 100 miles distant from the sea, and are only influenced by subterranean lakes. P.

“ Mr. Watt having fused a large quantity of basalt, in th centre of the mass which was slowly cooled, the crystals o basalt were large; but they grew less as they approached th surface, which was amorphous and vitrified.

“ The lava emitted from volcanoes is speedily decompose by the action of moisture and the atmosphere, and forms th most fertile soils. No countries are more productive tha those in the vicinity of volcanoes, if below the line of perpetual snow. The volcanic island of Santorin, which wa raised in the Archipelago in one night, in the year 1770, i now in part covered with a luxuriant vegetation, and n country in Europe is more productive than the lower declivities of Etna.

“ The operations of nature are on a scale too extended t be measured by days or years: they require ages to produc their full effect. What appears destructive and desolating a the first view, is found on a more comprehensive examinatio to be attended with permanent advantage. The lava and th ashes which burned Herculaneum and Pompeia, have furnished abundant harvests for fifteen centuries. The evil that nature inflicts are transient, but her benefits are of lasting duration.”

Space of volcanic appearances.

It is unnecessary to warn the reader that this extract is no from the hand of the excellent author, and that of course i is only the general current of the ideas which deserves attention. But as the Germans have too much restricted, o rather annihilated, the influence of volcanoes, it seems her to be rather too much enlarged: for if we suppose two hundred existing volcanoes, and compute the medium of thei agency at thirty miles each, the amount will be six thousan square miles, or at the most equal to the island of Sicily about seven thousand two hundred. But the extinct volcanoes would probably more than double this extent; and i seems certain that in the chaotic and ancient state of th globe, before the component substances had acquired thei present solidity and temperature, numerous volcanoes mus have existed, which have been totally and radically extin guished; while in modern times perhaps only two volcanoes wholly new have appeared, that of Jorullo, in New Spain, and that of Cahorra, under the peak of Teneriffe. The influence of heat in the chaotic state of the world is well explained by an able though anonymous author.

Chaotic heat.

"Incessant and infinite motions must have existed in chaos, from the universal operation of endless varieties of unsaturated attractions and repulsions. In those vast fluctuations, therefore, of universally intermingled and heterogenous particles, quantities possessing every order and degree of affinity must have come within their mutual spheres of attraction. The weaker affinities must have been overpowered by the stronger; and thus, in the process of time, immense quantities of uniform quiescent and digested masses of matter must have been produced: and in these formations do we trace the first rudiments of organised nature. In them we find the origin of earths, metals, acids, alkalis, water, and atmospheric air.

"Combustion, or oxygenation, is the grand and principal chemical process by which most, if not all, such compounds are by the new system of chemistry known to be formed; even water itself, so long supposed to be a simple element, is now proved to be the combination of hydrogen and oxygen by combustion. Nature every where presents proofs of the agency of fire in her primary combinations!

"As fire has been seen to be the first process of nature in the formation of digested masses out of chaos, so is water found to be the great organ of arranging these masses in the next operation of nature, in the formation of the spheres: and here may I not for one moment pause, to observe how admirably this reconciles the contending opinions of geologists as to which of these agents has been employed by nature? Each of these sects has produced innumerable arguments, innumerable documents and instances, to prove his theory; and, in truth, nature abounds in appearances, in examples, of the agency both of fire and water. In the demonstrations before us we behold each serving in its turn the great purposes of nature; we behold the one employed in the *individual* combination of substances, the other in the *general arrangement of the whole.* We behold the contradictory opinions of theory, and the diversity of appearances in nature, connected and harmonizing with the truths of modern chemistry!" [*]

Newton's idea.

Nor must it be forgotten that our ideas of a chaotic state seem to be confined to this globe only, instead of being at least extended to our solar system. And if we conceive, with La Place, that the planetary bodies were formed by the concretion of an aëriform fluid, emanating from the sun, which derives its splendour from the Deity, the fountain of light, human imagination can never conceive the universal effervescence and developement of various vapours and gases, which must have appeared in the primeval universe. But in this and other grand ideas the prince of modern philosophers will ever be found to lead the way, having thus expressed himself in his immortal PRINCIPIA. "The vapours which arise from the sun, the fixed stars, and the tails of comets, may fall by their gravity into the atmospheres of the planets, where they may be condensed and converted into water and humid gases; and afterwards by a slow heat graduate into salts, and sulphurs, and tinctures, and mire, and mud, and clay, and sand, and stones, and corals, and other earthy substances." [†] Did not this eagle of intuition thus foresee the pneumatic chemistry?

The important geological observations of Dr. Davy on the subject of volcanoes also excite, and may authorise, some other general remarks on the theory of the earth, which will not, it is hoped, be found wholly digressive.

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[*] Sketch of a New Demonstration of Nature, London 1810, 8vo.

[†] Vapores autem qui ex sole, et stellis fixis, et caudis cometarum oriuntur, incidere possunt per gravitatem suam, in atmosphæras planetarum; et ibi condensari, et converti in aquam et spiritus humidos: et subinde, per calorem lentum, in sales, et sulphura, et tincturas, et limum, et lutum, et argillam, et arenam, et lapides, et coralla, et substantias alias terrestres, paullatim migrare.

NEWTON *Princ. part* ii. *prop.* 42.

however, from the external constitution, the predominant central substances are iron and silex, or the metal of silex. For silex itself, as already explained, is frequently a new production, found in the straw of graminous plants and the bark of the bamboo. Nay, pebbles of quartz are found in the bamboo itself; and often of the size of a pea in the eggs of the ostrich*.

Ferrara's theory.

Ferrara's able account of the volcanoes of Sicily has also opened some new geological ideas. In one passage he thus expresses himself: "The natural philosopher who has explained the formation, that is, the condensation and consolidation, of the globe, and the inequalities of its surface, as being produced by operations arising from an innate power in matter, from a power most generally diffused, from a power to which nature has put no limits of action upon the spot which we inhabit, but at the same time destined to bind all the parts of the universe together, in order to form a well-regulated whole; in a word, by gravitation: it would seem that he approaches nearer the verisimilitude of causes: he does not leave the earth in order to explain the facts which are found in it; he has not created extraordinary powers; but has attributed all the phenomena to agencies which still operate, although upon another scale, but which would renew the same phenomena, if they were conducted under the same circumstances. From what I have said it may be understood that my opinion is with those who suppose that this globe was formed of materials which, being first diffused in a fluid, were thence deposited successively, and which occasioned all the disorder which we observe on the surface by the sinking of some parts, while others remain elevated in their original site and level. Burnet, who not long since started this grand and perhaps ancient idea, has been followed by many natural philosophers who have given it all possible extension, and, from physical truths and exact observations, have conducted this theory to a degree of verisimilitude of which the others are not capable. I adopt it, not only as it appears to me the most consonant to the theorems of natural philosophy, but as I find it most proper to give the most natural and easy explanation of the facts which we observe in Sicily, and which seem to add additional proofs to those observed in other regions."*

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* See Barrow's Cape of Good Hope. Breislak, ii. 205, may be consulted for the dissolution of silex, which he says is effected by water impregnated with caloric, soda, and sulphur in a state of vapour. Kirwan, i. 155, says, oxyd of iron with microcosmic salt yields a pale green glass, that is, a siliceous substance.

Subsidence.

Bouguer, and many other naturalists, have observed, that in South America the plains have palpably subsided, and left the rocks elevated in many fantastic forms. It is indeed to be conceived that the earth, originally in a fluid state, as appears from the depression of the poles, and many other circumstances well known in natural philosophy, and replete with innumerable vapours and gases, could only acquire its present comparative solidity by prodigious subsidences, arising from the gravitation of the solid and semifluid parts towards the centre. The most prodigious of the subsidences must have been that which sunk two thirds of the globe to make room for the present oceans, sufficient receptacles for the primeval waters, if the idea of this vast subsidence can be supported. Ferrara, arguing only on that subsidence which gave place to the Mediterranean, says that the mountains above Reggio are very sensibly inclined towards the sea, which indicates that their base sunk to form the channel which divides Italy from Sicily. He also observes, that the inclination of the strata towards the sea may be seen in all the mountains which border the southern side of Sicily†. The following passage likewise deserves observation: "Where the mountains are formed of soils in which the lavas are united with the calcareous masses, or, to explain myself more clearly, where a frontier of consolidated lava was filled from the bottom to the top with calcareous masses, the series of these heights is calcareous on the one side, and volcanic on the other. Such is the mountainous mass, terminating in the summit, upon which stands the village of Carlentini. To suppose, with Dolomieu, that the lava pressed through the vale, whence, rising by the side, it arrived at the top, without having passed to the other side, is to suppose an order of things which can never have existed at the epoch when the lava was fluid. In fact, this division does not exist when you proceed towards the west, above Lentini, where the lavas cover all parts, that is, the volcanic stratum covers all that extent. The same phenomena are observable in the mountains of Canzaria, near Vizzini, and in some which are in the plain of Marineo, beyond Licodia. In all these stratiform mountains the position of the strata of similar materials corresponds from one mountain to another; a circumstance which may be estimated by the eye, where the breadth of the valleys is not too great. This circumstance demonstrates the character of the revolutions which have produced these inequalities." * He afterwards proceeds to state the sinking of a part of a mountain in 1536, and the catastrophe which happened at Nicosia about 1750, when a fourth part of the city, with the convent and churches of the Capuchins, sunk in one day, so that nothing could be seen but the tops of the buildings, and of the trees; but the people escaped by stepping out of the windows. In 1740 the town of Salemi suffered the same misfortune; and in 1790 some lands sunk near S. Maria di Niscemi. He also states that the people of a place, a few miles to the west of Catania, thirteen years ago could only see the top of the cupola of the Benedictine monastery of that city, the prospect having been impeded by the lava of 1669, but now the entire cupola is seen, the chalky soil under the lava having subsided †.

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* Ferrara, 354.

† Ferr. 371, 374.

Perhaps this doctrine of subsidence might of itself explain the inequalities and other phenomena of the earth's surface, without having recourse to any concussion of a satellite or other body. The summits of basalt, and the caps of lime-

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* Ferr. 376. † Ferr. 378.

stone, in the Tyrolese, might perhaps be explained in this manner, and we are at least certain that the cause exists. But it is far from the intention of this work to propose or support any theory; and these remarks must only be regarded as a few scattered hints which may interest the reader.

Pini's system.

Pini, in what he calls a new theory of the earth, supposes a nucleus surrounded with a fluid zone, which contained the elements of the various substances; and he imagines the effects and variations to have been very prompt and sudden, owing to the extreme rapidity of the rotation of the earth. He argues for a formation wholly aqueous; but his chief new fact seems to be a granitic mountain at Gana, in Austrian Lombardy, which is throughout full of cavities, a few inches distant from each other, and lined with crystals of quartz and felspar *.

De Luc's.

The chief features of De Luc's new system of geology seem to be the following. He supposes that during the deluge the former continents disappeared; but this is clearly contrary to the Mosaic account of paradise, and the whole scriptural narrative, which represents the land as stable and unalterable. That successive catastrophes affected the beds of our continents, even while they were rising under the waters by chemical precipitations, being occasioned by caverns which formed under them. That valleys, lakes, abrupt precipices, existed at the birth of our continents, in consequence of those catastrophes by which the beds were ruined. That stony masses and gravel, which are scattered in such great quantities upon the continents, are also original features, and do not arise from currents; the flints proceeding from beds of chalk dissolved; and the gravel, as well as the large blocks, caused by the attrition of fragments, have been expelled from the interior by expansive fluids, during the subsidence of the beds, and dispersed at the same time at the bottom of the sea. That the precipices towards the sea have not been produced by the sea itself, but are original features,

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* See the Opuscoli Scelti, tom. xiii. Milan 1790, 4to. p. 369, 379.

resulting from the rupture of the beds, at the time of the vast subsidence which sunk the former continents, and produced the new concavity of the ocean.

These theories may be compared with the Wernerian and Huttonian, and that of Ferrara, founded, as he says, on that of Burnet. The rocks having been hitherto considered as the chief province of the geologist, it is hoped these few cursory remarks will not be found foreign to the purpose. But Petralogy, as already observed, has little more connexion with Geology than its sister sciences Lithology or Metallogy; and, like them, can only be regarded as an introduction. In which point of view these observations may not be found unuseful to the student. But it is time to return to the description of the Accidential Domains, an accurate knowledge of which may be regarded as peculiarly indispensable to any system of geology, such theories having so often confounded the pride of human science. The more humble sage will perhaps be contented with the knowledge of the substances themselves, and prefer what Gibbon calls a LEARNED IGNORANCE to any geological theory.

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DOMAIN VII.

COMPOSITE.

◆

THIS division comprehends the rocks which consist of different substances blended together, and for which no distinct denominations have been adopted. Many of them have been classed under vague names, particularly that of granite.

General observations.

Under the division of Aggregated Rocks, Gmelin, in his edition of Linnæus, has ar-

Gmelin's plan.

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hat it is theoretic, and constructed upon
eological ideas of the antiquity and forma-
ions of the several rocks; which the suc-
essive and general observations of future
ges may perhaps demonstrate to be only
ocal, or erroneous; and which, even at
resent, are very far from being univer-
ally admitted. Nay, if they proved to
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cientific work, the same substances being
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ondary, nay, sometimes of independent
rmations; while, in any science, all that
required is the knowledge of the object
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re confounded, and no accurate know-
dge can arise. In any science, on the
ntrary, it is necessary that the objects
e classed, and most precisely defined, be-
re even a plausible system can be con-

ranged granite, gneiss, porphyry, amygdalite, bricia, and sand-stone; and the reader will be surprised to find what various and discordant objects are united under these vague appellations. Mr. Kirwan has, in like manner, two titles of Aggregated and Derivative Stones; the other rocks being considered under the simple substances.

Werner's theory.

Daubuisson supplied Brochant with a short account of rocks upon the plan of the Wernerian geology, or, as it is called, geognosy, not by the most fortunate term, for the Gnostics have been celebrated for sixteen centuries as only pretenders to knowledge. But Werner is, on the contrary, the most able and sagacious observer that the science has ever produced; and his observations will continue valuable to the latest posterity. His reputation cannot be injured even by the insolent tone of his disciples, who seem to say, " Are we not sons of the wise, and shall not knowledge die with us?" Daubuisson has however treated this subject with great modesty and accuracy. The fault in the plan is,

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logical ideas of the antiquity and forma-
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trary, it is necessary that the objects
classed, and most precisely defined, be-
even a plausible system can be con-

structed: the stones must not only be hewn out of the quarry, but most accurately squared, before the temple can be erected. But true science and theory are so completely opposite, that any attempt to blend them has always defeated its object.

To Mr. Jameson we are greatly indebted for a more ample account of the Wernerian theory of rocks, which he has illustrated with considerable care and attention, so as to form by far the most complete treatise on the subject which has yet appeared. But an infinite number of rocks occur in nature, which have neither name nor local habitation in the Wernerian system, nor in the Huttonian; though no science can be called complete without enumerations of all its objects, and in the present instance one neglected rock might perhaps suffice to overturn a theory. The greatest misfortune in the progress of human knowledge has always been, that theories have been constructed before facts have been observed. The theories are indeed useful, of rocks, arising from local relations, must always be regarded as empyrical, and will often prove wholly erroneous. That great observer, Saussure, found, in the ample scene of the Alps, that he was farther removed from the formation of a theory, after the sedulous labour of forty years, than at the beginning; that instead of any regular plan or order, he found perpetual contradictions, in the assemblage and coalescence of substances, that seemed to be wholly remote and dissimilar. "It may well be affirmed," says he, "that there is nothing certain in the Alps, but their variety. . . . . Sometimes the skirts are calcareous, sometimes magnesian. The centres and highest summits are here of massive granite, there of a calcareous mica slate; sometimes of magnesian stones, sometimes of gneiss: if the beds be considered, here they are vertical, there horizontal; here their inclination follows the slope of the mountain, there quite the contrary."* We may add, from more recent observations,

Saussure's remarks.

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* § 2301.

that the summits of the Pyrenees are of a shelly and fetid marble; while the Andes are chiefly composed of clay, and pour out rivers of mud. When we compare these grand scenes with the little mountains or hills of Saxony, we must regret the perverseness of fate, which has confined Werner to such an insignificant field of observation. Nor can the travels of his disciples affect the question, for many have changed their sentiments upon their visits to Auvergne, and other volcanic countries; and observations of the great master alone merit confidence; for we all know, from Hogarth, how Richardson could read Greek through his son.

These introductory observations are not unnecessary in passing to new and grand divisions of the rocks, which have been blended and confounded under several vague denominations, but which are here separated into various great assemblages, for the sake of more clear detail, and more accurate knowledge.

Pretended granites.

Under the important Mode of granite,

it has already been explained that felspar and quartz, united with siderite or mica, or with both, are indispensable attributes of that substance. The mica may pass to micarel, or even steatite; and the appearance of schorl or garnets, not to mention the gems, cannot be considered as altering the nature of the substance.

But the name granite has, on the contrary, by Gmelin and many other writers, been extended to almost every aggregation that can be conceived. Such heterogeneous aggregations are here arranged under the name of Composite Rocks; while some, as that beautiful rock called the Corsican granitel, are placed among the Anomalous, as departing from the usual rules observed by nature.

Substantial and Accidental Divisions.

The latter six great divisions of the rocks, being derived, not from the *nature of the substances* themselves, but from *accidences* or circumstances, may be called ACCIDENTIAL, or circumstantial; while the former divisions are SUBSTANTIAL. The chemical *Mode* therefore, so essential in the substantial ranks, here becomes foreign to the object; and the terms *Structure* and *Aspect*, derived from the self-apparent nature of the stones themselves, would become yet more improper, as by far the greater part of these rocks are even compounded of various domains, united in one mass.

New terms necessary.

The term DOMAIN has been retained, not in its former acceptation, which may strictly imply the preponderance or predominance of a particular earth or substance; but in a more general sense, equally applicable to all the twelve divisions; that is, merely a continuation of the metaphoric language of the Mineral Kingdom, Provinces, and Domains. In this sense it is indeed chiefly used in the first six divisions; the other implication, of predominance or preponderance, being of a secondary and subsidiary nature, and only a further recommendation of its propriety.

But the term Mode implying the chemical mode of combination, which is even more essential than the nature and power of the substances combined, as appears from an infinite number of analyses, it cannot be admitted into these new divisions, derived from accidental, and not from substantial, differences, as has been just mentioned; and the inferior terms being equally objectionable, the adoption of a new appellation becomes indispensable. The word NOME has been adopted, as short and convenient, and as applied by the Greek writers to the districts of Egypt, the first country where chemistry and mineralogy appear to have been studied. It is therefore not only of classical authority, but has an affinity, so to speak, with the parent country of the science, and thus presents scientific recollections*. The author has the greatest aversion to unnecessary neology, the chief use of language being to be understood, and that the thoughts may be accurately perceived, as flowers or fruits

Nome.

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* The word in all its relations seems strictly Greek, and is probably only a translation of a Coptic word, especially as Strabo informs us that the Nomes were divided into Toparchies.

in a vase of crystal: but when a science has assumed a new aspect, like chemistry, or is wholly new, like mineralogy, new words become indispensable to express new ideas.

For the sake of memory, and easy reference, the latter divisions follow the general succession of substances in the former: but this arrangement must not be understood to imply that any substance is predominant, as either may have greater or less importance in different parts of the same rock. After these considerations, the proper arrangement of the Composite Rocks will not be attended with much difficulty.

NOME I. SIDERITE, WITH GARNET ROCK.

Siderite and garnet are substances of similar origin, alike influenced by iron; and their conjunction is naturally to be expected. Nodules of garnet rock may appear in a rock of siderite, or the reverse; but both are so equally balanced, that it would be improper to class them under either Mode.

HYPONOME I.

Garnet, in a base of siderite.

HYPONOME II.

Siderite, in a base of garnet.

Siderite, with garnet rock, from Scotland.

The same, from Sweden.

NOME II. SIDERITE, FELSPAR, GRAPHITE.

A little chain of rocks, amidst the eternal snows of Mont Blanc, consists of laminar black or green siderite, felspar, and graphite, with a little quartz and mica*.

NOME III. SIDERITE, UNCTUOUS QUARTZ, PYRITES.

Mont Broglia, a southern spur of Mont Blanc, is of a stone softer than granite, being a mixture of siderite, felspar, mica, unctuous quartz, and pyrites†.

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* Sauss. 1974.

† Ib. 911.

NOME IV. PORPHYRY, WITH CHALCEDONY.

The green porphyry, in particular, sometimes appears spotted with chalcedony, so as to assume the form of a composite rock*. Ferber, it has been already observed, saw numerous blocks of green porphyry at Ostia, the sea-port of Rome, where they had been disembarked in ancient times, and neglected after the empire fell a prey to barbarians.

NOME V. JASPER, WITH AGATE AND CHALCEDONY.

This curious rock is described, by Petrini, as consisting of these three substances, in veins of white, green, red, yellow, purple. It admits a beautiful polish, and is found at Monte Rufole, in the Volterrano†.

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* In the noble collection of Besson, at Paris, there is a specimen joined with pure transparent quartz, which had probably passed as a vein through the rock.

† Gabinetto Nazareno, Roma 1792, 2 vols. 8vo. ii. 258.

NOME VI. MICA AND ACTINOTE.

A composition rather uncommon, but found in primitive regions, abounding in mica slate.

Mica and actinote, from Mount St. Gothard.

NOME VII. ACTINOTE, SIDERITE, MICA.

A composite rock of delphinite or actinote, greenish siderite, felspar, and white mica, all in little grains or plates*.

NOME VIII. QUARTZ, SIDERITE, OXYD OF IRON.

A rock, composed of quartz, siderite, mica, and oxyd of iron; together with a tabular felspar, which he calls *sanidine*, a substance in silky tufts, which he calls *desmine*, and another resembling spinel, which he calls *spinelan*, was discovered by Nose on the banks of the lake of Laach, near Andernach. See his mineralogy of the mountains of the Rhine, quoted in the *Jour-*

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* Sauss. § 1293.

NOME XII. FELSPAR, QUARTZ, TALC.

This noble rock contains plates of splendid talc, varying in size from half an inch to many feet in diameter. It chiefly occurs in the Uralian mountains, whence talc has sometimes been called Muscovy glass.

NOME XIII. FELSPAR, FIBROUS SIDERITE.

A rock in confused veins of felspar, white mica, and green fibrous siderite*.

NOME XIV. FELSPAR, CALCAREOUS SPAR.

A rock of great rarity, and seldom occurring except in the ejections of Mount Vesuvius, which also affords a composite stone of felspar, garnets, and actinote; with other aggregations on which it would be tedious to enlarge. Nor is it certain that they occur in such masses as to constitute rocks. Many may be mere parasites or vein stones.

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* Sauss. § 1359.

NOME XV. JAD, SCHORL, GARNETS.

A rock, which Saussure calls a mixture of jad, sparry schorl, and massive garnet. It takes a fine polish, and its large spots of red, green, and yellow, form a beautiful effect *.

NOME XVI. GRANITE AND CHALCEDONY.

Chalcedony was chiefly found in amygdalites, and by some supposed to be of volcanic origin. Saussure † discovered this curious and important rock near the city of Vienne, in Dauphiny. On examining the stones employed in building a peasant's cottage, he was astonished to find that most of them were elegant chalcedonies, more or less translucent, and mingled with leaves of a beautiful yellow pyrites. Observing that granite adhered to many of these fragments, the rock was explored, forming the adjacent bank of a rivulet called Bougelai. In some places it filled up the accidental seams of the granite, and in others formed nodules completely enveloped in that substance. The most common

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* § 145.

† § 1634.

colour of the chalcedony is a bluish grey; but it also appears of a yellowish white, and often covered with ferruginous rust. Sometimes there are zones, concentric and in festoons, of a paler colour. The fracture is various, sometimes uniform, sometimes scaly, sometimes a little conchoidal; and its hardness is such that the file cannot touch it. It is coeval with the granite, for nodules of granite may be found in the chalcedony, as well as the contrary. These granitic nodules contain very little mica, but abundant felspar, yellow or reddish, and quartz, of which the aspect sometimes approaches that of the chalcedony. The pyrites is interlaced in a remarkable manner, being in plates nearly regular, a quarter of a line in thickness, and about five or six lines in length. These plates cross each other in certain places, in every direction. Each of the plates is included in a kind of salband, of a breadth equal to that of the plate, of a deeper coloured chalcedony than the rest of the stone. The pyrites is of a pale brass colour, and granular fracture, but decomposes in the air; so that its beauty only becomes apparent on a fresh fracture*.

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* Saussure afterwards discovered abundance of chalcedony in the granites and gneiss of the plains, and particularly in the ancient Bourbonnois. See tome v. p. xi.

In a subsequent journey Saussure also discovered gneiss, its thin leaves alternating with thicker or thinner leaves of chalcedony.

HYPONOME I.

Chalcedony in granite.

HYPONOME II.

Nodules of granite in chalcedony.

Micronome 1. Gneiss, alternating with chalcedony.

NOME XVII. GRANITE, WITH SCHORL AND GARNETS.

A granite, from Bamfshire, Scotland, of red felspar, and bluish fat quartz in large grains, broad plates of micarel of a brilliant yellow, with black schorl in prisms of four lines in diameter. There are also patches of garnets.

NOME XVIII. GRANITE AND LIME-STONE.

This mixture, like most of the others, appears in the Alps.

HYPONOME I.

Granite, with lime-stone.

Micronome 1. Gneiss, with lime-stone.

NOME XIX. GRANITE AND SLATE.

Slate, by some called argillaceous schistus, is sometimes found blended with granite, though in general it rather seems to form a distinct line; and it commonly rests on granite, as being of a more recent formation. The veins of granite that run through slate have afforded matter of discussion to various theorists, who thence argue that the granite is of more recent formation, or at least that they are both coeval. It has been affirmed by some, that what is called granite, in such instances, is of an imperfect form, being either granitel of two substances, or the mica not in its usual state of crystallisation. Granites

Veins of granite in slate.

Saussure's remarks.

of quite a new formation have been indicated by Saussure*. In describing the mountains which bound on the north-west the valley of Valorsine, he mentions that he found a mountain composed of his *roche de corne*, which is sometimes basalt, generally basaltin, sometimes basanite, sometimes magnesian basaltin, here called Saussurite; and sometimes a coarse slate, or argillaceous schistus, which seems here to be the case†. "On observing this *roche de corne* in the spots where it coalesced with the granite, I saw veins of different breadths filled with a granite, which was formed and moulded in their interior. The largest of these veins is about three feet in breadth, cutting at right angles the planes of the layers of the rock, which it traverses; and the uncovered part above the rest is about seven or eight feet in length. The sides of this vein are regular and parallel. The granite which fills this vein is composed, like that of the mountain to which it adheres, of grey quartz, white felspar, and brilliant grey mica. This granite presents little even slits or seams, rather indicated than real, crossing each other in different directions; which seems the effect of a beginning recess; and which show the tendency, common in this sort of stone, to divide itself into fragments of even sides.

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* § 599. 601.

† The *corneus fissilis* of Wallerius is hornblende slate, or slaty siderite.

"Above and beneath this vein there are others more narrow, one in particular, which is not above half an inch in breadth, and is prolonged, like the former, for a space of seven or eight feet. Some of the little veins show that the beds of the *roche de corne* have subsided, or sunk unequally, since the granite penetrated into it; for they seem to be suddenly interrupted, and to begin anew a little higher or a little lower. The broadest vein seems also to have yielded a little in some parts.

"These veins of granite, which were then new to me, appear to throw light on the formation of that stone. For to any man a little versed in mineralogy, it is almost demonstrable that this granite has been formed in these veins, by mere filtration of the waters, which, in descending from the mountain of granite, which hangs over these schistose rocks, brought down the elements of that mountain, which they deposited and crystallised in these fissures. When one finds the slits of a marble, or of a slate, filled with spar or quartz, one decides, without hesitation, that these foreign bodies, or parasitical, as Linnæus calls them, have been brought by the waters, and crystallised in these slits. Since then the elements of granite are all capable of humid crystallisation, why, as the circumstances are the same, should one hesitate to acknowledge, that it has been also dissolved and crystallised through the medium of water?

"I thought then that I had made a great step towards the knowledge of the formation of granite, when I saw with so much clearness that nature could form it by the mere assistance of water. My only regret was, that the proof of this truth was concealed in the centre of the Alps, in a spot so little accessible to the greater part of the lovers of lithology.

"But I had, towards the end of the same year, the pleasure of finding the phenomenon in a place well frequented, and of easy access, since it is at the foot of the walls of the city of Lyons. If, without the gate of the Red Cross, you descend to the Saone, by a path which runs under the walls of the city, you will see on the right, a little beneath the fort of St. John, banks of sand, the sides of which are open to the air. Under these sands are schistose rocks, composed of white quartz and brilliant mica, sometimes red, sometimes blackish. The layers are almost perpendicular to the horizon, for they form with it an angle of 80 degrees inclining towards the west, and running from north to south.

"There I found a vein of granite 21 inches in breadth, and uncovered for a length of about 18 feet. This vein, of which the sides are parallel, traverses the layers of schistose rock, under an angle of 30 degrees, and forms with the horizon an angle of 50 degrees, with the same inclination as the layers. The granite which forms this vein has shrunk, like that of Valorsine, with some rectilinear fissures, which cross each other irregularly. There are seen in the same rock other veins of granite, of a less considerable size, the largest being parallel to that which I have described, while the others run in an oblique direction.

"I observed similar veins in the schistose rock, at the foot of the wall of the city, and under the path which accompanies that wall. One of them, about fourteen inches in breadth, is perpendicular to the horizon, like the layers of the rock. It passes under the wall, and must enter into the city. Near the Saone, and within the city, is a quarry of granite, which was wrought at the time I made my observations.

"In fine, I made at Semur, in Auxois, an observation analogous to the preceding, and which confirms the same truth that granite may be formed in the water, by the simultaneous crystallisation of two or three kinds of stone. The granite rock, on which this town is built, naturally divides itself into large masses, with plane or flat sides, and these masses are here and there separated by crevices of a certain breadth. I found in these crevices parcels of quartz, felspar, and mica, mingled as in granite, but in far larger grains, there being bits of an almost transparent quartz, two or three inches thick, traversed by leaves of mica so large that they might be called talc, or Muscovy glass; and the whole intermingled with large pieces of red felspar, like that of the granite, and confusedly crystallised. It could not be doubted, on seeing these heaps of large crystals, that they are the produce of the rain waters, which, passing through the granite, have dissolved and carried down these different elements, and have deposited them in these wide crevices, where they are crystallised, and have formed new stones of the same kind. The crystals of these new granites are larger than those of the ancient, on account of the repose which the waters enjoyed in the inside of these reservoirs."

Such are the remarks of this great observer, who proceeds to argue that granite was originally formed in the ancient ocean that covered the earth; that it is disposed in beds or layers, though sometimes very thick and difficult to discover, especially as those of the lower mountains are apt to split into fragments, either rhomboidal, or at least with flat sides, which he ascribes chiefly to the mixture of argil in one of his *pierres de corne;* and as he mentions that it is frequent in these granites, he must mean hornblende or siderite: adding, that the absence of marine bodies in granite, gneiss, &c. affords no proof that they were not formed under water, the most ancient ocean probably having contained no animated matter, as a pure infusion, for example, only displays animalcules at the end of a certain time.

Scarcely a phenomenon in orology has escaped Saussure, if his work be accurately read, or rather studied, as it well deserves; and what is regarded as a new observation may be here found, namely, the elevation of the veins of granite above the clay-slate, which, in his wide field of observation, he simply accounts for by the subsidence, or shrinking, an accident common to clay; not to mention the greater softness of the substance, which may more easily be worn down by the weather. Nor is it inconceivable, on the other hand, that those veins may be as ancient as the massive granite; that substance sometimes rising into natural walls, as in Cornwall: or, in the great antiquity of the earth, the veins may have been formed in a softer granitic substance (more compact veins and nodules being observable on a small scale), which afterwards wasted away, and its place was supplied by the clay-slate.

HYPONOME I.

Granite in slate.

Micronome 1. Slate in granite.

NOME XX. GNEISS, WITH BLUE SIDERITE.

Near Breuil, Saussure observed a gneiss full of garnets, the surface being incrustated with little crystals of a beautiful steel blue, oblong, irregular, opake, very brilliant, striated in the longest direction, frequently porous in that direction, and with difficulty scratched by a knife when the streak is grey. The fracture laminar, equally blue and brilliant; and they are easily fusible under the blow-pipe into a shining black amel, attractable by the magnet, although the original substance be not. He adds, that all these properties characterise some kinds of hornblende, the only singularity of this being its blue and brilliant colour[*].

NOME XXI. CLAY, SPATHOSE IRON.

A composite rock of clay, spathose iron, and another spar[†].

NOME XXII. SERPENTINE, WITH LIME-STONE.

Some of the most singular compounds with lime-stone occur in the Pyrenees, where that substance forms the chief summits. The intermixture of lime-stone, or of calcareous spar, with serpentine, is there not uncommon.

Some of the noblest marbles, as the verd-antique, and that lately discovered in Anglesea, consist of serpentine mingled with carbonate of lime; but the magnesia is so preponderant, and its nature so predominant and characteristic, that such are arranged in the Talcous Domain; not to mention that the union is too intimate to class them among the Composite Rocks, which are mostly only coherent, the substances forming in distinct accretions.

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[*] § 2274.

[†] § 1446.

HYPONOME I.

Dark green serpentine, with grey lime-stone, from the Pyrenees.

Micronome 1. The same, with red calcareous spar, from the same.

NOME XXIII. LIME-STONE, WITH GARNETS.

This curious mixture also chiefly occurs in the Pyrenees.

Light brown lime-stone, with red garnets, from the Pyrenees.

HYPONOME I.

With amorphous garnet.

HYPONOME II.

With crystallised.

NOME XXIV. LIME-STONE, WITH STEATITE.

Tirey, one of the western isles of Scotland, presents a white marble with yellow spots, supposed to be steatite.

In the same interesting isle marble and steatite are reciprocally interveined.

HYPONOME I.

Marble, with veins of steatite.

HYPONOME II.

With spots.

NOME XXV. LIME-STONE, WITH OLIVINE.

Olivine, before chiefly observed in lava and basalt, is also found in the micaceous lime-stone of Mount Somma, of which Vesuvius may be regarded as only a portion. Breislak has, on this occasion, given some useful information concerning olivine and chrysolite*.

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* i. 150.

Olivine and chrysolite.

1. The soft chrysolite, or asparagus-stone of Werner, is a mere phophate of lime, analysed by Vauquelin.

2. The chrysolite of the jewellers is a greenish oriental topaz.

3. The common chrysolite, or peridot of the French, analysed by Vauquelin, contains—magnesia 50, silex 38, oxyd of iron 9. This is also the chrysolite analysed by Klaproth.

4. Olivine, called by some volcanic chrysolite, has also been analysed by Klaproth, and though it contained rather more silex and iron, as the proportions will even vary in different specimens of the same identic substance, it must be regarded as the same with the peridot. There is also found a tincture of lime in olivine, which may proceed from the gangart. These gems are remarkable as alone belonging to the Magnesian Domain.

The jacint of Vesuvius, the Vesuvian of Werner, is also found in the lime-stone of Somma; and it has been discovered in Siberia, and in the mountains of the Grisons. Melanite has also been found in the calcareous rocks of Somma. But the latter substance is only to be regarded as imbedded in the rock, and strictly belongs to gemmology.

NOME XXVI. LIME-STONE, WITH ACTINOTE.

Tirey marble.

The beautiful rose-coloured marble of Tirey not only contains large crystals of siderite, sometimes an inch and a half in length, of a black or very dark green colour, but numerous other crystals of a lighter green, which every candid observer would allow to be the same substance, with a slight diversity of colour. It seems now to be universally allowed by the most skilful mineralogists, that actinote is only a diversity of siderite, with a greater portion of magnesia, an earth which singularly affects the green colour. But this actinote must not be confounded with the epidote of Haüy, a mistake into which many writers have fallen, whereas the latter contains no magnesia, and a greater quantity of lime*. Under the epidote he ranks zoisite, so called from Baron Zois; and the scorza, or greenish sand, found near Muska, in Transylvania. The sahlite he ranks under pyroxene, or augite. These substances are mentioned because they have been supposed to have been found in the marble of Tirey, which sometimes also presents a substance resembling red garnets; or perhaps they are only altered by the gangart, and might be found upon analysis to correspond with those found in the lime-stone of the Pyrenees. Thus the singular appearance of the flint discovered at Menil Montant, near Paris, and which resembles pitch-stone, probably only arises from the soft and unctuous marl in which it is always found. This important observation may be said to have escaped all writers on mineralogy.

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* See his *Tableau comparatif*, Paris, 1809. 8vo. notes 51, 55.

It is remarkable that marbles similar to that of Tirey occur in Scandinavia. A northern mineralogist, Mr. Neergard, observes that there are, in all Sweden and Norway, only two quarries of marble which are wrought*.

"That of Fagernich, in Sweden, is situate between the two little towns of Norkiöping and Nykiöping, and about thirty leagues from Stockholm. It belongs at present to Mr. Eberstein of Norkiöping, and to Baron Unger, who purchased it from Count Gyllenberg for only 200,000 francs, on account of its bad condition. This marble, which is white, with veins of green talc, the fracture brilliant, began to be wrought about a hundred and fifty years ago, in the reign of Queen Christina. The space where it is found is about 2000 fathoms in length, but its breadth is inconsiderable. They make of it tombstones, slabs for tables, vases for butter, salt cellars, and mortars; and the sale of these different articles amounts annually to about 20,000 francs. There are magazines of it at Stockholm, at Gottenburg, at Carlskrona, and at Abo. The manufactory employs about twenty workmen, who receive each two livres ten sous (about two shillings) daily; and its position is fine and well adapted for working, as it is near the Baltic sea.

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* Brard, Traité des pierres, Paris 1808, 8vo. ii. 444.

"The marble-quarry of Gillebeck, in Norway, is seven leagues distant from Christiana; but as the marble which it furnishes is saturated with a great quantity of pyrites, it generally becomes decomposed in a few years. The great church of Frederick, at Copenhagen, which is unfinished, is built with this marble. I have often seen some pretty tablets of it, which contained garnets, and a green substance called actinote."

The Tirey marble seldom takes a fine polish. Perhaps by a mill, or a steam-engine, and high friction with putty, this defect might be remedied. But granite itself seldom admits a perfect polish, owing, as in the Tirey marble, to the different hardness of the ingredients. Besides, our artisans, only accustomed to soft marble, seldom possess the instruments necessary for hard substances; and a laudable change in the public taste can alone drive them from their routine.

NOME XXVII. MARBLE, WITH ASBESTOS.

This uncommon mixture is found in the Pyrenees, and, it is believed, in Sweden.

HYPONOME I.

Marble, with asbestos.

Micronome 1. Asbestos, in calcareous spar.

DOMAIN VIII.

DIAMICTONIC.

General observations.

THESE rocks, in which the substances may be said to be chemically combined, form the most difficult province of the whole science, and might deserve a separate treatise, like the *Cryptogamia* of the Botanists. Siderous earth, for example, may be found so intimately and equally combined with the siliceous, that the rock cannot with propriety be arranged under either. The celebrated glazed rock, which Saussure observed near the monastery of St. Bernard, is of this description; and there is a specimen in the author's collection. It has been called an intimate combination of quartz and *roche de corne.*

Derivative rocks.

Most of the Derivative Rocks of Kirwan belong to this Domain. The name and idea he is said to have borrowed from Bergman. The aggregated stones of Kirwan comprehend granite, gneiss, porphyry, amygdalite, sand-stone, and other substances, visibly compounded of various materials; while his derivative stones he distinguishes from aggregates by this, "that the associated ingredients are not visibly distinct, or at least require microscopes to render them so." He adds, that a derivative stone may be denominated from the *species* (that is, the Mode), which still predominates; but if it participate equally of both, it may receive its denomination from either. The siderous, siliceous, and argillaceous earths, form the most frequent combinations; while those of calcareous earth and magnesia are far more rare. In his Geological Essays he observes, that stones are either original, as granite, or derivative, as sand-stone; while, in his mineralogy, he has classed sand-stone, along with granite, among the aggregates.

The appellation and distinction are in fact alike fallacious. That a red sand-stone may be derived from the detritus of a red granite, may be justly admitted; but this affords almost the only example of a real derivative stone. And the intimate combinations of which Mr. Kirwan speaks are so far from being derivative, that they often belong to the most original and primitive substances. But when Mr. Kirwan published his valuable system in 1794 (and the last edition is merely reprinted), the knowledge of rocks was extremely confined, and regarded only as an appendage to mineralogy, instead of forming a grand and distinct science, a rank to which its dignity and importance authorise it to aspire

The term *diamictonic*, derived from the Greek, implies that two or more substances are so thoroughly mingled, or, in the language of chemistry, so intimately combined, that the rocks cannot be arranged under either Domain, either from preponderance or predominance.

As this Domain depends especially upon the guidance of chemistry, it may be chosen to honour the names of the chief chemists, here arranged in chronological order, from the most ancient to the most modern times[*].

NOME I. SIDERITE, WITH SILEX.

[HERMITE, from *Hermes*, the supposed founder of chemistry, which certainly originated in Egypt.]

Of this kind is the celebrated rock above mentioned, in which atoms of quartz are intimately blended with atoms of siderite; but in some portions, as usual in the infinite variety of nature, the quartz will preponderate, and sometimes the siderite. Saussure's description is as follows:

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[*] A curious account of the ancient chemists, or alchemists, may be found in the *Histoire de la Philosophie Hermetique* of Lenglet Dufresnoy, Paris, 1742, 3 vols. 12mo.

Glazed rock.

"We now arrived at this singular rock, which formed the object of this excursion. Its superior surface inclines to the east, under an angle of 43 degrees. It is this surface which is polished, and in so bright a manner, that it forms a perfect mirror. In some parts it is perfectly plane, so that tables might be cut from eight to ten feet in length, and of a proportional breadth; while in other parts it is a little undulated, but still equally polished. It is here veined like a marble; there marked with angular spots, like fragments enchased in a base. The colour varies, the ground being commonly brown or blackish, and the spots of a pure white; sometimes however the ground itself is white. This stone is very hard, yielding abundant sparks under the flint, whence the polish resembles that of an agate or a jasper, having more splendour than that of marble. The white parts are undoubtedly of semi-transparent quartz, infusible by the blow-pipe, but dissolving very speedily, and with a lively effervescence, in mineral alkali. The black parts appear of two kinds; those which are nearest the polished surface losing their colour under the blow-pipe, and becoming white like the former, but without any further change; and they also melt with effervescence in the mineral alkali, without colouring it in the slightest degree. But in the interior of the stone are found black and soft parts, which, when moistened with the breath, exhale an odour of clay, and melt under the blow-pipe. The black polished parts are therefore also of quartz, or, if you will, of jasper, coloured by some particles of the black *pierre de corne*, which is found in the interior of the rock."

He supposes that the most natural explanation of the polish is, that it arises from crystallisation on a vast scale, as it is accompanied with streaks, like those common in crystals of quartz.

NOME II. SIDERITE, WITH MICA.

[DEMOCRILITE, from *Democritus* the philosopher, B. C. 480, who made many experiments on plants and minerals.]

The particles of siderite are sometimes intimately blended with particles of mica.

NOME III. SIDERITE, WITH FELSPAR.

[FIRMICITE, from *Julius Firmicus*, who flourished under Constantine I. and first mentions alchemy, "*scientiam alchemiæ*[*]."]

Graustein. The graustein of Werner is an intimate mixture of siderite with white felspar, which last often predominates. According to Mr. Jameson[†] it contains olivine and augite, like basaltin, and sometimes passes into that substance. It is frequent near Vesuvius, and in some other parts of Italy.

NOME IV. SIDERITE, WITH EARTHY FELSPAR.

[SYNESITE, from *Synesius*, one of those Greek philosophers, in Egypt, who cultivated this science, A. D. 400.]

This combination has been described by Saussure. The mixture of siderite and felspar, in basalt and granitel, may be considered as a gradual approach to this intimate combination.

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[*] Matheseos iii. 15. Orosius first states, that Diocletian burnt the books of the Egyptians.

[†] iii. 190.

NOME V. FERRUGINOUS QUARTZ.

[Zozimite, from *Zozimus*, one of the chief Greek philosophers of Egypt, who wrote on alchemy, A. D. 420.]

Near Sallenche, Saussure observed a rock, with protuberances, of a lively red, like cinnabar. When broken with a hammer it proved to be a micaceous ferruginous rock, with irregular nodules of quartz, tinged red with iron.

When the tender or micaceous part of this stone was exposed to the flame of the blow-pipe, it melted into a greenish and almost transparent glass; but the hard and quartzy parts scarcely suffered any change, except there were some free ferruginous particles, which in that case melted, and formed a black and brilliant dross, on the surface of the stone; but when the colouring part is intimately combined with this stone, it remains red and untouched[*].

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[*] Sauss. 1134.

NOME VI. BASALTIN, WITH EARTHY FELSPAR.

[GEBRITE, from *Geber* (Abou Moussa GIABER ben Haijam al Sôfi), the first of the Arabian chemists, A. D. 830.]

Saussure afterwards describes another singular diamictonic rock, which he found near Mont Blanc.

" Fragments of a remarkable rock are afterwards observed; its colour is red, inclining to violet, like the dark lees of wine; it is not schistose, but in hard and compact masses; yields fire with steel. In the fracture its grain appears a little scaly; and if observed with a lens, it is found mixed with dull grey parts. These parts, softer than the rest of the rock, become white when scraped with a knife, and are unquestionably of *pierre de corne*. As for the hard and reddish base, it seems to be of the same nature with that of several porphyries, which have been improperly classed among jaspers. The blast of the blow-pipe discolours and melts it, though with difficulty, into a transparent glass, strewed with small bubbles. This cha-

NOME VIII. BASALTIN, WITH SILEX.

[Ebensinite, from *Eben Sina*, or Avicenna, A. D. 1020.]

The siliceous part is generally felsite. Basaltin sometimes passes into a more siliceous substance, which, in the north of Ireland, is schistose, and contains ammonites. It is supposed to be a detritus of the basaltin, mixed with siliceous particles in the primeval waters.

NOME IX. BASALTIN, WITH WACKEN.

[Albertite, from *Albertus Magnus*, A. D. 1220.]

considerable part of the combination; but the rock still preserves the slaty appearance.

NOME XII. SLATE, WITH MAGNESIA.

[VALENTINITE, from *Basil Valentine* (his real name see Dufresnoy, i. 229), A. D. 1410.]

This substance is commonly to be distinguished by its unctuous or silky appearance. The magnesia sometimes assumes the form of small scales, as at Holyhead, where it is also sometimes invested with a crust of foliated steatite, and sometimes includes masses of pure talc and amianthus*. The same interesting spot likewise presents schistose siderite, penetrated with talc or micarel. It has commonly layers of quartz between the plates of siderite.

NOME XV. QUARTZ, WITH BASALTIN.

[Torricellite, from *Torricelli*, A. D. 1640.]

This is a scarce rock, and may rather be referred to the mixture of siderite with quartz.

NOME XVI. QUARTZ, WITH SLATE.

[Glauberite, from *Glauber*, A. D. 1650.]

A diamictonic rock, composed of quartz, impregnated with slate *.

NOME XVII. QUARTZ, WITH FELSPAR.

NOME XVIII. KERALITE, WITH CHLORITE.

[Kunkelite, from *Kunkel*, A. D. 1660.]

This combination often forms the green keralite, one of the most pleasing appearances of that substance.

NOME XIX. SCHISTOSE KERALITE AND SLATE.

[Boylite, from *Boyle*, A. D. 1660.]

The colour is grey, of a greater or less tendency to blue.

NOME XX. SCHISTOSE KERALITE AND LIME-STONE.

[Beccherite, from *Beccher*, the great founder of modern chemistry, whose *Physica Subterranea* appeared at Frankfort, 1669.]

This seems chiefly to happen where the primitive lime-stone joins the schistose keralite.

NOME XXI. STEATITE, WITH ARGIL.

[Stahlite, from *Stahl*, 1700.]

Dr. Babington informs us, that this substance is harder, and less unctuous, than common steatite, and has an earthy smell when breathed on. That of Cornwall is of a dark olive-green colour, and slaty texture*.

NOME XXII. OLLITE, WITH SILEX.

[Pottalite, from *Pott*, of Berlin, who first analysed stones and earths, 1730.]

This kind is described by Mr. Kirwan†. The

NOME XXIII. SERPENTINE, WITH SIDERITE.

[BLACOLITE, from *Black*, 1760.]

This compound is usually of a blackish colour, and the fracture rather foliated, or striated. That of Portsoy is of a greenish black*.

NOME XXIV. SERPENTINE, WITH BASALTIN.

[BERGMANITE, from *Bergman*, 1780.]

This substance is black, and the fracture splintery. It might perhaps be classed among the Sideromagnesian Rocks.

NOME XXV. LIME-STONE, WITH ARGIL.

[KLAPROTHITE, from *Klaproth*, 1790.]

This combination sometimes occurs in marbles; for example, in that of Campan in the

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* Bab. ut supra.

Pyrenees, which from its remarkable structure however may partially be classed among the Anomalous Rocks. Its decomposition in the air, so visible in the pillars of the palace at Trianon, is owing to the mixture of argil, which imbibes moisture. Karsten, in his description of Leske's Museum, mentions granular lime-stone, mixed with clay-slate, from Kunnersdorf, in Upper Lusatia.

HYPONOME I.

Marble of Campan, &c.

Micronome 1. Lime-stone, with argil.

NOME XXVI. LIME-STONE, WITH GYPSUM.

HYPONOME I.

Massive.

HYPONOME II.

Schistose.

NOME XXVII. LIME-STONE, WITH SILEX.

[BERTHOLITE, from *Berthollet*, 1800.]

Concerning the calcareous stones Mr. Kirwan observes, that " when mixed with siliceous particles in considerable proportion, they effervesce with acids but slightly and slowly, and their fracture tends to the conchoidal, but often also to the earthy; of this we have a remarkable instance in Leske, s. 229. Its lustre, 0. Hardness, *scarcely 9.* Fragments, 3; which indicates the siliceous ingredient. Its sp. gr. only 2,254; which shows it to be of the nature of sand-stone. Heated to 141°, it did not form a lime, nor did it melt. When the lime-stone is of the granular kind it has more lustre, and is much heavier, see Leske, s. 1098. But when the particles of silex are in a smaller proportion, or not purely siliceous, the lime-stone presents a different appearance: thus the lime-stone, Leske, s. 1769, seems as if passing into hornstone, and is of a yellowish grey colour. Lustre, 0. Transparency, 1. Fracture, fine, splintery. Fragments, 1. Hardness, 9. Sp. gr. 2,640. It effervesces briskly with acids, but melts into a greenish grey compact enamel.

"Effervescence with acids is not therefore a sufficient proof that a stone will burn to lime: thus the dark bluish-grey stone, Leske 0. 1229; whose lustre is 0; transparency, 0; fracture, uneven and splintery; fragments, 2; sp. gr. 2,740; hardness, 9; and which contains the impressions of various shells, and effervesces very briskly with acids, yet melts into a black compact glass. It has an earthy smell when breathed on."*

NOME XXVIII. GYPSUM, WITH MARL.

[VAUQUELITE, from *Vauquelin*, 1800.]

Gypsum often forms veins in hardened clay or marl, and is sometimes penetrated with the latter substance. Instances may be found at the Old Passage, near Bristol.

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* Kirwan, i. 373.

NOME XXIX. GYPSUM, WITH SILEX.

[DAVITE, from *Davy*, 1810.]

Marble of Vulpino.

To this division belongs the noted marble of Vulpino, analysed by Fleurieu de Bellevue*. It is of an uniform whitish grey, sometimes veined with a bluish grey. It forms no effervescence in the nitrous acid, though it has the exterior aspect of a saline marble. When the powder is thrown on burning coals, it yields a slight but easily perceivable phosphoric light. Its specific weight amounts to about 200 French pounds for each cubic foot. It is quarried at Vulpino, 15 leagues from Milan, and is employed with success in that city in making tables, columns, vases, or other works of that kind. Before the analysis it was regarded as a marble.

HYPONOME I.

Uniform.

HYPONOME II.

Veined.

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* Brard, ii. 474. Patrin, iii. 222.

G. Cooke fecit

Glacier of Miage.

DOMAIN IX.

ANOMALOUS.

◆

General observations. AMIDST the infinite variety of nature there are many rocks which, though sometimes composed of not unusual modes, are of so singular a structure, that they deserve to be ranked in a separate Domain; more especially as the greater part are of distin[illegible]ished dignity and beauty. Others are [illegible]tled to this distinction from their gem-waters, or deposited by them, or appearing as mere efflorescences, or at the most in a gemmose form. And as the important and interesting study of Crystallography, or Chrystallogy, originated from the observation of the salts, they may be considered as belonging to that department of Lithology.

Coal. But the Combustibles stand in a different predicament, for coal is, in many countries, a very common and abundant substance; is found in vast beds, like many other rocks; and may be said to constitute entire hills, as that of St. Gilles, near Liege. In this new point of view, therefore, coal has been ranked among the rocks; and that division also includes the bituminous substances, which ouse from them, or may be found in their recesses; while amber and mellilite remain almost alone for the minute investigations of the gemmologist.

Pyrites. In passing to the sulphuric substances it must be observed, that a most common and general appearance of sulphur, in pyrites, is so interwoven with most of the rocks, that it forms an important feature substances, bounded by a single black line about half a line in breadth, followed by a broader circle of the felspar. In others the centre is dark grey, bounded by two narrow black lines, followed by a broad circle of lighter grey, succeeded by a black band, about a line and a half in breadth, followed by the white of a quarter of an inch. But the most beautiful glandules, as well as the largest, are those which present a narrow black line, like a hair, on one or both sides of the black band.

Site. This most singular and beautiful of all the rocks was, it is believed, first described by Besson, a venerable mineralogist, formerly Inspector General of the mines in France*. But Patrin informs us that it was discovered by Barral, a French engineer employed in Corsica; being merely a large solitary block, found, by Besson's account, beneath Olmetto: but as there are many places of that name in Corsica, the indication is not distinct†. So imperfect was then the knowledge of rocks, that Besson supposes the siderite to be steatite. The felspar may however be mingled with quartz, as he and Pabeautiful stones which I have ever beheld. The largest blocks, and there were some from 30 to 40 feet in diameter, were of a granitello, composed of white felspar and black schorl* in plates. These two kinds of stone were mingled in all the proportions, and under all the forms imaginable. Upon one, were large parallel fillets of the purest white and black; on another, nodules of the most beautiful black, surrounded with concentric veins alternately white and black. Others presented veins in zigzag, between parallel veins. Those which astonished me the most by their structure, were the stones which displayed parallel layers, terminated by other layers which cut them at right-angles, without any appearance of rent or subsequent junction, the block appearing completely uniform†. I greatly regretted that these beautiful masses were not within the reach of a manufactory, where they might be sawn and cut, to make vases, and above all tables, which would be of the most perfect beauty. For there is no marble which can approach to these stones in regard to the size of the veins, their extreme precision, and the bright-the bottom of the waters, horizontal beds, afterwards raised up by a great revolution, and lastly divided by the effects of time. Eleven years of observation and meditation have served to confirm me in that opinion."*

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* Journal de Physique, 1789.

† Saussure says, § 1479, that the ocular granitel of Corsica was discovered by Sionville; and Saussure intended to have described it, when he was prevented by Besson.

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* The language of that time for hornblende or siderite.

† So quartz sometimes appears in clay slate.—P.

It is evident that one of the singular rocks above described, that with concentric zones of black and white, is the same which was found in Corsica. It might be styled OCULITE, or *Ophthalmite;* but as agates, and other substances, sometimes assume that form, it was thought advisable, as a new name is indispensable for so singular a structure, to term it Miagite, from the place where it was discovered by Saussure.

This excellent observer afterwards discovered similar rocks on the glacier of Lauteraar.

Glacier of Lauteraar.

"Not being able to survey these ridges, I observed at least the wrecks with which the glacier is covered, and which come from these ridges, or their vicinity. Some of these fragments are of common granite, others of veined ble. Among them are the variolites of Drac; and another variolite, of laminar siderite, of a dull black inclining to green; spangled with crystals of felspar, sometimes rhomboidal, sometimes circular, with green dots of hornblende towards the centre. Saussure observes, that it somewhat approaches to the ocular granitel of Corsica, the crystallisation being only more confused.

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* Sauss. § 892, 893. In § 899, mentioning granular felspar resembling granular quartz, but melting under the blow-pipe, Saussure adds, that in the beautiful granitel of Miage the felspar is also confusedly crystallised, but its white and sparry plates are evident; whereas here it is disguised in the form of a sandstone.

The following detached observations of this skilful Petralogist, may throw additional light on this subject. He supposes, § 159, that layers in zigzag probably arise from crystallisation, as they do in alabasters: and § 2227, he mentions layers in zigzag, in a granular lime-stone, mixed with mica, included between other veins which are parallel. Such layers, he adds, are not only found in crystallised rock, but in slate, which presents no appearance of crystallisation.

The ocular appearance is also found in other rocks, and Faujas has formed a series of this kind. Saussure indicates, § 161, mica slates often containing nodules of quartz, which, when cut across, appear like eyes. Sometimes they are as small as grains of millet; and others are two inches in diameter.

An ocular serpentine is also found in Corsica.

successful, so that the smallest pieces of this stone are extremely dear."*

This is truly surprising; and affords a further proof, if necessary, that the ingenious writers of France, with their clear heads and universal talents, never think it a duty, though it be indispensable, to read preceding accounts, that they may not repeat what is already well known; nor, above all, want the necessary knowledge of their subject. For to write on any science, without a complete knowledge of what has been already done, can in few instances contribute to its real advancement, which ought to be the chief end of every publication. The glacier of Miage, where so many beautiful varieties of this rock occur, cannot exceed two French leagues, or six British miles, from the little town of Cormayeur, on the river Doire; a distance surely not invincible for sledges or other conveyances: and any man of common enterprise might soon disperse these beautiful stones all over Europe. The fact is, that the passage of Saussure had totally escaped notice; and at present is only known to M. Sage, and a few other mineralogists, to whom it was indicated by the author.

It must not be forgotten that, in whatever

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* Brard, ii. 287.

HYPONOME I.

Ocular Miagite.

Micronome 1. With straight lines.

Micronome 2. With zigzag.

Micronome 3. Dendritic. This is the beautiful stone only found in the ruins of Rome, the *Nera e Bianco,* falsely called a granite.

NOME II. NIOLITE.

Faujas, in his late interesting work of geology, is the first who has described this singular rock, of which he has also published a coloured plate*.

lisation, of which numerous examples occur in the rocks and stones.

"To distinguish perfectly the interior organisation of these balls, and discover the manner in which they have been formed, it is necessary to cut, with iron wire and emery, some plates off the rock, so as to reach if possible the centre of the balls. They must then be slightly, but not highly, polished; the former being preferable for this kind of rock, as it renders its lineaments more clear and distinct. It is then evidently seen that the interior of these balls is solid, composed of compact felspar or felsite, of a white tinged with rose-colour, disposed in rays, or rather petals*; being flat imperfect crystals, terminating in sharp points, and diverging from the centre to the circumference. An envelope, about a line in thickness, of a lighter felsite, surrounds the globules; and, when divided by the saw, this envelope presents a circular line, which encloses and circumscribes each disk, serving as a kind of frame. The flowers thus displayed then produce a beautiful effect; and if it were possible to obtain large pieces of this rock, to saw in the form of a table, or turn in especially as Niolo is celebrated for various beautiful stones*.

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* *Petalum* means a thin plate; and was originally transferred from metals to the leaves of flowers in botany.

NOME III. CORSILITE.

This beautiful rock being also from Corsica, it was thought proper to propose a geographical name; and an island so eminent in the history of the rocks, well deserves this distinction.

Description. The rock now in question is a most beautiful mixture of greyish white, with the most delicate emerald green, which presents at the same time a satiny appearance. According to Werner, it is a mixture of felsite, or compact felspar, with actinote. Among the Italian artists, it has been long known by the name of *Verde di Corsica;* and Ferber, in his intelligent travels through Italy, 1772, informs us that "the *Verde di Corsica* is no marble, but a hard rock, striking fire with steel, of a white substance, with blackish or violet spots, and large grass-green sherl crystals, of a sweet colour. Large tables of this fine position is found at Serviere, above Briançon; but the diallage, or smaragdite, is black, yellow, bronze, grey, or silver-grey*. In other instances, the diallage has a metallic splendour; and the author has a specimen, which he received from Faujas, of a rock composed of serpentine and felspar, containing metallic diallage; and which was discovered by the Marquis de Cubieres, in the ruins of Pompeia; so that scarcely a beautiful rock can be said to have escaped the researches of the ancients: and the ruins of Rome are found to present about two hundred and fifty kinds, while those of London would only afford white marble.

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* Even in the large maps of Bacler Dalbe, Corsica must be imperfectly represented, for Niolo, and other names often mentioned, are not to be found.

The most complete account of the beautiful rock here called Corsilite, may be found in Patrin's ingenious system of mineralogy. The

Smaragdite.

smaragdite, he observes, was formerly called *mother of emerald;* and sometimes appears to have passed even for emerald itself. This substance is a singular combination of many constituents, as may be judged by the following analysis, by Vauquelin, of the green and grey smaragdite; a name which might be retained as a compliment to its great observer, and as the green is its most usual and beautiful colour.

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* Brard, ii. 309.

vided into two modes, *axinite* and *lemanite;* the former, as Haüy has quite a different axinite (a crystal from Oisans), might be called *pelekine*, from the Greek term for a battle-axe*; for it implies the green substance wrought in that form, from New Zealand, and from South America, where, as described by Condamine, it forms the real stone of the Amazons: a tribe idly so called on the Maranon, or river of Amazons, because the women upon one occasion defended themselves, while their husbands were absent in the chase. This substance has been analysed by Hoefner, who pretends to have found 38 of magnesia; but his authority is absolutely null: and this interesting substance remains a problem.

Pelekine.

Lemanite.

The lemanite, which bears the same aspect, has been analysed by the younger Saussure, who discovered no magnesia, but a considerable proportion of argil†: and it is possible that even the green kind, for that colour often indicates the presence of magnesia, may, like the Iconite of the Chinese, analysed by Klaproth, contain no magnesia, but merely an unctuous argil. The lemanite receives its name from the lake Leman, commonly called that of Geneva.

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* Πελεκυς, *bipennis.*

† Silex 44, Lime 4, Argil 30, Oxyd of iron 12,5, Soda 6,=96, 5.

being sometimes of a greyish white, sometimes inclined to lilac; the smaragdite is disposed in small masses, which never exceed one or two inches in diameter, and is of a beautiful velvety grass green.

"The base of the third picture is of a most extraordinary beauty; it is at least 4 feet long, and 28 or 30 inches in height. It is almost entirely composed of pure smaragdite, of a dark green, and yet of the most beautiful semi-transparency, which has a more imposing effect than if perfectly transparent, by the varieties which its mixture forms with the jad. The latter is in small quantity, but spread in the form of little undulating leaves, as thin as paper, and as white as milk. As the stone has, with much ingenuity, been cut obliquely to the planes of these leaves, their extremities are seen on the surface, and in proportion to their depth in the smaragdite, they assume, by imperceptible degrees, the beautiful green colour; which, added to their undulating and festooned form, and their disposition in little masses near each other, makes them resemble in a singular manner the beautiful foliage of trees, and, in other parts, the waves of the sea gently agitated."*

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* Patrin, Min. i. 163.

this as the most beautiful of all. It is found near Autun, in the department of the Saone and the Loire, and particularly at Marmagne. There is also found, in the environs of Autun, a white graphic granitel, with little crystals of grey quartz. Champeaux, an engineer of the mines of France, discovered the rose-coloured kind of Marmagne, of which small tables might be formed.

Sites.

That of Corsica is of a yet paler rose-colour than that of Autun, while the crystals of quartz are larger and more distant from each other. There are also some specks of bronze-mica, which do not occur in that of Marmagne; but it is capable of an equal polish.

That of Scotland is of little importance, as the crystals of quartz are distant, and not sufficiently apparent. It is found near Portsoy.

That of Siberia appears in two distant sites: the Uralian mountains to the north of Ekaterinburg, and in Daouria near the river Amur; the felspar being of a yellowish, or reddish white, laminar, and glistening*. It is charged with crystals of smoky quartz, which may be compared to Runic letters; and is accompanied with

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* *Chatoyant*, derived from the eye of the cat; it has scarcely a corresponding term in English. Refulgent?

NOME V. LAZULITE ROCK.

Of this magnificent and interesting object, a better account cannot be given than in the words of Patrin.

Description. "The *Lapis lazuli*, often simply called *lapis*, is a rock of a beautiful sapphire blue, generally mingled with veins and spots: it sometimes contains pyrites, which was formerly mistaken for grains of gold; and spangles of mica, in greater or smaller quantity. This rock is hard: the blue parts are quartzose, and strike fire with the steel; the white veins are of felsite, sometimes mixed with calcareous spar or gypsum; in some parts are to be perceived, in the tissue of the substance, brilliant plates like those of hornblende.

"The Lapis, which abounds with the blue substance, is wrought into various trinkets and other ornaments; although granular, it is capable of receiving a very fine polish.

Ultramarine. "A valuable colour for painting is prepared from the Lapis, known by the name of Ultramarine; because it is brought from the trading towns of the Levant. The blue colour is very vivid and intense; and, above all, possesses the inestimable property of being unalterable. It is to the ultramarine that we are indebted for those rich tints, so much admired in the skies and draperies of the first masters.

"The Lapis is found in several countries, but in very small quantities; that which furnishes the most is Great Bucharia; it is from thence that it was brought to Russia, where it was so profusely used to ornament the marble palace, which Catherine the Second built at Petersburg, for Orlof, her favourite. There are in this palace some apartments entirely lined with lapis. It would be scarcely possible to imagine a decoration more simple, and at the same time more magnificent. Site.

"I met with, at Ekaterinburg in Siberia, a dealer in stones, who had been at Bucharia: I inquired of him concerning the nature of the mountains, whence the Lapis is brought*. He informed me that it was found in granite; that it did not run in veins or streaks, but was disseminated in the entire mass of the rock, in all sorts of proportions; that here only a few slight bluish spots were perceivable upon a rock generally grey; there the spots were closer, and of a more lively tinge: in fine, small masses were found of an almost entire blue; but that it was extremely rare to discover pieces as large as one's head, in which the blue should generally predominate over the white and the grey. As those blocks, which I had seen, appeared to me rolled, I asked if they had been found in the beds of rivers; and was informed they were taken from the quarry, and that they were rounded by their friction against each other in the carriage; but that sometimes, however, they were found by chance in torrents, and these were of the most brilliant blue.

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* It is said to be found near Kalab and Budnesh, in Bucharia.—P.

"Laxmann, an academician of Petersburg, who resided several years in Eastern Siberia, said he found rolled blocks of lapis upon the shore of the lake Baïkal, in a kind of gulf, to the southward, called Koultouk; but that he in vain sought for the mountain from which these blocks had been detached, and that he could get no information from the Buret Tartars, who inhabit this savage country. I have a specimen of this lapis, which is exactly similar to that of Bucharia.

"Boetius de Boot has given a long account of the manner of preparing ultramarine. This operation consists chiefly in the repeated calcination of the lapis, and plunging it in vinegar: he adds, that the oftener these calcinations are repeated, the finer the colour. That of the first quality was sold, in his time, at 20 dollars an ounce, which is dearer than gold.

“ Dufay, of the Academy of Sciences, has found the lapis when exposed to the sun, and afterwards brought into the dark, to give a phosphoric light; and that the purer and deeper the blue, the stronger the phosphorescence. The grey and white kinds have not this effect.

“ In some mineralogical systems, lapis was classed with zeolite; but a further knowledge of the nature of these two substances, has again separated them.

“ The lapis has sometimes been confounded with the Armenian stone, which is totally different, and is nothing more than a fine mountain blue, or oxyd of copper; and the colour which is extracted from it, though fine at first, has not the durability of ultramarine.

“ The analysis of lapis lazuli yielded to Klaproth :

“ Silex	46	
Argil	14	50
Carbonate of lime	28	
Sulphate of lime .	6	50
Oxyd of iron . .	3	
Water	2	
	100.”	

Sapphires of the ancients.

The lazulite appears to have been the sapphire of Pliny, which was spotted with gold; and ancient engraved gems have been found of this substance. Wad mentions two Egyptian monuments of this stone; being little statues, an inch or two in height.

Werner's lazulite.

The lazulite of Werner, found at Varau in Austria, and in Salzia or Salzburg, is a different substance, recently arranged with the blue felsite of Krieglach in Stiria. But Haüy regards it as distinct*. The lazulite here described, is the *lazurstein* of Werner.

HYPONOME I.

With deep blue lazulite.

HYPONOME II.

With whitish.

NOME VI. GRANITE WITH SAPPARE.

This rock has only been recently observed. The sappare is in small spangles, of a lively blue, being interspersed among the common ingredients of granite.

Saussure informs us, that he first received this substance from the Duke of Gordon, among other Scotish minerals; who informed him, at the same time, that the Scotish name was sappare*. Werner (whose fondness for the worst of all nomenclatures, that derived from accidental colours, has been ably ridiculed by Mr. Chenevix), has, forgetting all due respect to the great name of Saussure, most needlessly changed this denomination for *Kyanite*, or blue stone!

NOME VII. LABRADOR ROCK.

The celebrated opaline felspar, originally, as is said by some, discovered by the Missionaries in the transparent lakes of that country, while others affirm that it is only found in the Island of St. Paul, to the south of Labrador, has scarcely

* § 1901.

yet been observed in the parent rock, which is only inferred to be a kind of granite. Another rock containing opaline felspar, but of far inferior beauty, has been recently observed in Norway. The felspar is conjoined with a very hard reddish substance, which has been inferred to be quartz.

First appearance.

In the Bee, a periodical paper, published at Edinburgh in 1793, by Dr. Anderson, there is a curious account of precious stones by Dr. Guthrie, physician to the corps of Noble Cadets at Petersburg, presenting some interesting particulars concerning those found in Siberia. A correspondent of Dr. Anderson's has added a letter concerning the first appearance of the Labrador stone; which, being little known, shall be subjoined.

" The coast of Labrador is a cold inhospitable country, bordering upon Hudson's Bay; and was granted by George II. to a religious sect of people, called the Moravians, who solicited and obtained it, in order to convert to their way of thinking the few inhabitants who had settled along the sea coast; but they soon discovered a more material advantage in cultivating the fur-trade, which they do at present to a very considerable extent. About ten years ago, another unlooked-for source of wealth started up, and which, if it had been properly managed, would have proved little worse than a silver mine. Some of the English settlers, walking along the borders of the inland rivers, observed particular stones of a shining opaline colour; these when slit, or cut in a mill and polished, displayed all the variegated tints of colouring that are to be seen in the plumage of the peacock, pigeon, or most delicate humming-birds. Some of these beautiful stones being sent as a present to their friends in England, soon attracted the notice of the lovers of the fine productions of nature, who bought them up with avidity. From England the same desire spread all over Europe, and every collector was unhappy till he could enrich his collection with specimens of different colours, which are no less than seven, often mixed with varying tints and shades. Some of the larger specimens have four distinct colours upon the same slab; but more generally each stone, as found in the lump, has its own particular colour, and which most commonly runs through the whole. The light blue and gold is the most common; green mixed with yellow, is the next; fire with a purple tinge, not so common; the fine dark blue and silver, still less; and fine scarlet and purple, least of all. The largest specimens yet discovered are about three feet in circumference; and all over one continued gleam of colour. I have seen many blocks of it greatly larger than the above, but they had only spots of colour here and there, thinly scattered. The first quantity that was exposed in Edinburgh, was in the year 1790, in a ware-room on the south bridge, by one Shaw, from London, a native of Aberdeenshire, who, I think, keeps a shop of natural history in the Strand; and was the same person who sold that wonder of nature, the Elastic Stone, to the Honourable Lord Gardenstone, and which his lordship, with his usual goodness, sent to the ingenious Mr. Weir, and now forms a part of his elegant Museum in Prince's Street, New Town, Edinburgh. Mr. Shaw again paid us a visit so late as November 1792, when he exhibited some most brilliant specimens of Labrador spar; particularly one of fine, extremely bright, and variegated colours; one pretty large, of the scarce fire-colour with the purple tinge; and one with gold, blue, and green shades: the first was sold to the celebrated Dr. Black; the two last are in the elegant collection at Morningside. This beautiful stone, when analysed, is found to contain a portion of calcareous matter, and some particles of silver and tin*; some pieces bear an exceeding high polish, but very soft upon the surface, and may be scratched with a nail or file. Some naturalists ascribe the reason of the beauty of the shades and colours, to arise from a decaying quality in the stone; however that be, it has been turned to no other use than specimens for the cabinets of the curious, and inl snuff-boxes; but if a proper quarry be fou nd in Labrador, we shall have chimney-pieces o vhich will go beyond any thing the world h er seen, as to beauty and elegance. The h t price any single specimen has as yet sol , is twenty pounds; but a much finer coul v be purchased for half the money.

"John Jeans, the Scottish fossilist, lately discovered a spar very similar and much resembling the Labrador, in the shire of Aberdeen; but it only displays one colour, that is the gold tinge, and is of a much softer consistency; one of the finest specimens of which is to be found in Lord Gardenstone's cabinet of precious stones. This stone is arranged in parallel strata, which appear in certain lights to be of a greenish semi-transparency, and white opake, like the onyx, alternately; in other lights, there are seen light tints of a brilliant golden hue, with some very small spots like mica."*

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* A strange analyst!

HYPONOME I.

Noble Labrador, or opaline felspar.

Micronome 1. Norwegian blue.

NOME VIII. KOLLANITE.

Description.

This rock, which, if not the first, ranks among the first in beauty, consists of round or oval pebbles, or rather crystals, of various colours, in a siliceous cement, sometimes approaching to transparent quartz, at others itself a bricia of minute fragments or crystals. The most common colour of the pebbles is grey, followed by the brown, black, dark blue; the more beautiful, yellow and red; the rarest being the green. The cement is also of various colours, from the transparent quartz to the opake red; sometimes of a metallic yellow, perhaps from disseminated pyrites; at other times tinged with yellow or red around particular pebbles, or in distinct parts, arising from the influence of the oxyd of iron.

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* The letter is signed A. S. Bee, xv. 99. A few copies of the account of gems were thrown off separately, by Dr. Anderson, for his friends; they are very rare and valuable.

Pudding-stone.

This is the celebrated pudding-stone of England, so much in request in foreign countries; but this name commonly exciting a smile among the illiterate, and the appellation being since enlarged to a great number of glutenites, of a different nature and origin, forming entire chains of mountains (while this is confined to a very small district in England, and is found no where else in the world), it has been thought proper to distinguish it by the name of Kollanite; derived from the Greek*, denoting its appearance of being cemented together.

Noble flint.

The pebbles also, which are inlaid in this beautiful substance, seldom belong to common flint; but to an intermediate kind, between flint and chalcedony, which, in the imperfection of the science, has not yet been characterised. Karsten, in his catalogue of Leske's collection†, has mentioned, among the minerals of Poland, nine specimens of flint, chiefly yellow or spotted, which must greatly resemble to those in the Kollanite; and which, as he observes, approach exceedingly near to chalcedony. Many may also be said to be agatised; being disposed, like agate, in concentric lines of different tints and colours. It is indispensable that a new term be applied to this intermediate substance; and the Greek name of Chalite is proposed, from the word for flint, but which has not yet appeared in mineralogy*.

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* Κόλλα *cement*: it is also used by Dioscorides, and others, for iron, which in the mineral kingdom forms an almost universal gluten. See Collini *sur les Agates*, p. 156.

In words from the Greek, the original and English K is preferred to the Latin and French C.

† ii. 471.

Chalite.

To arrange these pebbles with common flints, would only occasion a confusion of ideas. They belong to an intermediate substance, between flint and agate, which indeed Haüy has arranged together, under the name of Quartz agate. That flint which is found near Paris, with the layers and beauty of an onyx, and that called menilite, might also be classed as different structures of this nobler kind of flint; which, as silex is from the Latin, might be sought, as before stated, in a higher source, the Greek, and denominated chalite. Like chalcedony or agate, to which it sometimes passes, according to Mr. Kirwan, it is often accidentally impregnated with jasper.

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* Χαλιξ. The Hebrew, it is said, is *chalamish*. Readers versed in that language, may cnosult Deut. VIII. 15. Ps. CXIV. 8. Is. V. 28. L. 7. Ezek. III. 9.

Detached pebbles.

These pebbles are often found detached, and of a particular beauty; which, wanting however the delicacy of some agates, resembles that of a rustic girl when compared with the elegance of high life. Some present circles and shades of various tints of brown, approaching to the Egyptian pebbles; others, various concentric lines of yellow and brown, yellow red and black; and others display a centre of red or crimson, with concentric bands of yellow and olive green. There is also a rare kind called the zebra, from its regular black bands upon a white ground. If we believe Dr. Woodward*, who made a very large collection of English pebbles, fine agates have been found near Gaddesden, in Hertfordshire, one of the boundaries of the pudding-stone; where have also recently been discovered some fine flints with purple illinitions, like landscapes, perhaps tinctured with manganese†. That industrious author informs us that the Kollanite is common about Berkhamstead, in Hertfordshire, where it is called the *breeding-stone.* Breeding stone. This is also the case at St. Albans (which, with its vicinity as far as Market Street on the north, may be regarded as the chosen district of the most beautiful Kollanite); the name arising from the common idea that this stone *breeds*, or produces successive pebbles. The *breeding-stone* must, however, be distinguished from the *mother-stone*, of the same county; which is an iron-stone, with pebbles of quartz, deposited in layers above the chalk; and sometimes approaching the surface, renders whole fields barren. Dr. Woodward also says, that at Aldenham, near Watford, Hertfordshire, this substance, there called *pudding-stone*, is very frequent; and some masses weigh near a ton; nay, he mentions a mass of three tons, at Corner Hall, near Berkhamstead; and that labourers about St. Albans speak of masses of a similar size*.

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* Nat. Hist. of English fossils.

† Collini observes, p. 146, that agates are easily detached from the rock, because each is enveloped in iron ochre. This remark applies to many kollanites.

Sites. From personal inquiries and observations, it appears that the fairest pudding-stone is chiefly found at the ancient and venerable town of St. Albans, where masses often occur in the pavement; and its northern environs, as far as Market Street, where it also forms a great part of the pavement. The masons of that time, not observing its beauty and singularity, have often mixed it with common flint, as it occurs in the neighbouring quarries, in the walls of the Abbey Church and its precincts, and in those of the nunnery of Sopwell. The author even found at the spot called Gorhambury Block, a piece which had fallen from the Roman walls of Verulam; being flat, like a Roman brick, with some mortar adherent. But as a beautiful and valuable stone, it seems to have been unknown till the seventeenth century.

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* Sites of little consequence, or erroneous, appear to be Two Waters, West Wycombe, the county of Berks, &c.

It is also said to have been observed in the bed of the River Lea, at Luton. The ingenious Mr. Parkinson, whose work on petrifactions is well known, observes in a letter to the author, "that towards Ware, in the south-east, and from Amersham to Kings Langley, on the south-west, I have sought for it in vain; but between Hemel Hampstead and Tring, I have seen large masses, which I suppose have been dug up in that neighbourhood. The flint containing Alcyonia, &c. ceases about Amersham; and soon after, I believe, rather more to the north, commences the pudding-stone." In short, if we take a line from St. Albans in the south, to Market Street in the north; and from Tring in the west, to Hatfield in the east; we shall have an oblong-square, of about 20 miles E. and W. and about 10 N. and S. which may be indicated as the peculiar district of the Kollanite, or precious pudding-stone.

Shells. Shells, or strong and marked impressions, have been found in the very centre of masses of Kollanite, which with its superincumbence on chalk (where however it only forms detached masses, like those of siliceous sand-stone, or granular quartz), have been regarded as proofs of its recent formation.

On Barnard Heath, near St. Albans, along with the masses of pudding-stone, which themselves always appear to have been rolled, may also be found bowlders of black jasper veined with white quartz, the siliceous schistus of Werner, with others of red jasper, of granular quartz, and even of rock crystal; so that the position would argue little, while the shells alone would evince it a secondary substance. They are commonly small chamites; and, it is believed, have never been discovered in the finest kinds. Mr. Parkinson* has observed, that the numerous pebbles found in gravel-pits, &c. have seldom been rolled; but, on the contrary, their present forms are precisely those which they at first derived from the siliceous impregnation of several animals, which existed in the primeval waters. He supposes that the pebbles were at first soft nodules of martial clay, or marl, often composed of laminæ of different colours; such, as he says, have been frequently found in the gravel-pits of England, and in large heaps in various parts of Italy. They are afterwards impregnated with siliceous juice, which may be of very recent origin; for silex is soluble in water, as appears from the analysis of many medical waters of England, not to mention the fountain of Geyzer in Iceland: and Mr. Davy has shewn that it enters into the composition of the epidermis of many reeds, and even of oats, wheat, barley, and other graminous plants; that of Dutch rush, in particular, seeming to consist entirely of silex. In stacks of burnt hay, there are found porous stones, resembling frits of glass. From these examples it can scarcely be denied that silex may often be produced from decayed vegetables. There may, however, be two formations of pudding-stone. The celebrated Fracastorius was the first neptunist, as he was the first who inferred fossil shells were not *lusus naturæ*, but formed by the primeval waters which covered the earth. But if these shells existed even in the primeval ocean, it would be difficult to assign

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* Organic Remains, i. 283.

Silex often recent.

the precise epoch of their creation; and thus a few shells might appear even in substances styled primary.

Origin of pebbles. That patient and careful observer, Saussure*, has established as an axiom, that pebbles originally so formed, and not produced by attrition, may be distinguished by their concentric layers, or by a nodule, whose form corresponds with that of the stone: thus what he calls *petrosilex à ecorce*, or with a rind, is a flint found in natural nodules, the rind being from six lines to an inch in thickness, of a grey almost opake; whilst the concentric kernel is of a fawn-colour, and semitransparent†.

With regard to rolled pebbles, the study of which he has particularly recommended, as perhaps more essential to the theory of the earth than that of the rocks themselves, Saussure has remarked, and the observation has since been repeatedly confirmed, that the pebbles of the vales among mountains are derived from the rocks of which these mountains consist; but the pebbles of the large open plains seem as if dropped from the sky, no parent rocks appearing in a space of hundreds, and even of thousands of miles‡. It would seem, from many circumstances, that while the primeval waters covered this globe, no particular oceans nor seas existed. Hence the currents of the chaotic ocean, of far more force and activity than we can at present conceive, have rolled these pebbles from immense distances, as products of Florida are by the gulf stream brought to Newfoundland, and even to Shetland and the Orkneys. De Luc has observed, that the stones scattered over the continents form a principal geological monument; and any theory which passes this phenomenon in silence, can deserve but little attention from the real naturalist*. So true it is that the plains are more difficult to illustrate than the mountains; and he who can explain the formation of a pebble, may explain the formation of the globe.

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* § 204. † § 1566. ‡ § 717.

Doctor Kidd's observations on the pebbles of England, deserve particular notice on this occasion†.

"The larger masses are in many parts of England called *bowlder* stones, a name expressive of the cause of their rounded form: the term *pebble*, is in common language applied to those which are smaller than the foregoing, but too large to be used as gravel; and these are very commonly employed for the purpose of paving court-yards of houses, and the streets of small towns. Common gravel is too familiar to need any description. Pebbles of the smallest dimensions constitute coarse sand.

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* Geologie, 351.

† Vol. ii. append. 29.

"The gravel immediately round London appears to consist almost entirely of the black flint met with in the neighbouring chalk strata: the pebbles are in general very uniformly worn, and have to a greater or less extent lost the characteristic black colour of the flint, from which they are derived; but sufficiently correspond with it to shew the identity of their nature.

"The gravel round about Windsor and Maidenhead consists also, in a great measure, of the flint of the surrounding chalk-hills; very much discoloured, but not much worn. It appears, however, that that part of this gravel which is nearest the surface is not of the nature of flint, but in its texture resembles a highly indurated sand-stone: and it is observed that these pebbles are much larger than the flint pebbles; and, though considerably harder, are much more uniformly rounded. They have probably, therefore, been conveyed from a greater distance; and judging from their relative situation, for they are found nearest the surface, they have been deposited more recently than the flint. It is worth observing, that pebbles of this kind are met with in almost every part of England. I have collected them from very different points along the course of the North Road, both on the eastern and western side of the island: from Nottingham, York, Durham, Edinburgh, Lanark, Carlisle, Chester, Shrewsbury, and Worcester; and have observed them in many other parts.

"The *gravel* met with immediately round *Oxford consists* principally of small siliceous *pebbles*; many of which are flint, mixed with worn fragments of fossil calcareous shells, and brown iron-stone; the presence of all these substances is accounted for by the nature of the surrounding country; the limestone of that district abounding with fossil shells, and many of the neighbouring hills consisting either of chalk containing flint, or of ferruginous sand containing brown coarse iron-stone."

But it is time to return from the consideration of the pebbles, to that of the rock under view, which has also been called a pebble-stone by some authors.

That there may be no suspicion of national prejudice, in the account of this singular rock (which not only surpasses most others in beauty and variety, but affords many important lessons in geology), we shall translate the description of Patrin; who had not only inspected the richest cabinets of Europe, but had resided for eight years in Russia and Siberia, which afford some of the most beautiful mineral substances.

Patrin's account.

"The most celebrated pudding-stone, and which on account of its beauty obtains a place in all cabinets of mineralogy, is found in some rivers of Scotland, in small rolled masses, which are seldom more than five or six inches in diameter. It is generally known by the name of the pudding-stone, or pebble of England.

"It is formed by an assemblage of small siliceous stones, the interstices of which are filled by gravel and very fine quartzy sand. The whole is united by a siliceous gluten, of an opake white colour, which is not easily perceptible without the aid of a lens.

"The pebbles which compose this beautiful pudding-stone, are at most of the size of a walnut, and oftener of that of a bean or an almond. They are coloured with various tints, but with a remarkable singularity; for these colours are disposed in concentric layers. It seems then that these pebbles are little flints, which have been formed such as they are, but in another matrix from whence they have been detached by the waters, and afterwards agglutinated by a quartzy fluid.

"The concentric layers which are observed in their interior, seem to demonstrate that it is not to friction and rolling that they are indebted for their round appearance. It even appears that their primitive form has been no ways altered; for the interior layers are not only parallel among themselves, but even always parallel to the surface of the stone, whatever may be its shape. It is not uncommon to observe some which are triangular, of which the interior layers present several triangles, one within the other, and always parallel to the surface of the stone. The most common colour of these layers, is yellow, red, white, and bluish; this latter tint is generally that of the surface of these little pebbles.

"There is a circumstance which seems to prove that these stones have not been tossed about by the waters for any long time; it is, that they are almost always observed mingled with fragments of flint, all the angles of which are sharp.

"With this pudding-stone are made boxes, trinkets, and beautiful little slabs, which by the variety of their colours, and the vivacity of their polish, are infinitely agreeable to the eye."*

Brard's account is as follows†: "The pudding-stone of England is composed of little pebbles round, oval, or elliptic, of the size of an olive, brown, grey, or yellow, imbedded in a cement of a grey, or of a chamois colour.

"This pudding-stone, which is highly esteemed in jewellery, is found in rolled fragments in certain rivers in Scotland.

"Although the pebbles, and still less the cement of this pudding, be not of a very fine paste, it nevertheless takes a most beautiful polish. It is wrought in many works of decoration; but is not fit for small jewellery, such as earrings, necklaces, &c. It is used with more advantage in making boxes, socles, handles of knives, etuis, &c."

He then proceeds to describe the pudding of Chantilly, which consists of far larger pebbles, of a deep yellow, bordered with a bluish black, in a cement of quartzose sandstone. A finer kind is found near Chartres, in the department of the Eure and Loire, composed of very small brown and black pebbles, united in a silex of a yellowish white. The pudding of Rennes, which he subjoins, has been shown by Patrin to be *merely* a spotted jasper. That of Chartres must be also the same described by the acute Patrin, as merely an oculated silex, a keralite, or hornstein of the Germans.

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* iii. 350.

† Traité des pierres precieuses, i. 122. Prais 1808, 2 vols. 8vo.

The pudding-stone of England, therefore, retains that singularity of composition, which has diffused its name through all languages, and been *admitted in* all works of mineralogy, in an *assumed* contradistinction to bricia, which consists of angular fragments.

Common pudding-stone.

But the learned and sagacious Patrin is himself mistaken, when he says that the pudding-stone is found in the rivers of Scotland. It is true that a rough pudding-stone, composed of rolled pebbles of granite, porphyry, clay-slate, quartz, trap, primitive limestone, and other original substances, in a cement generally ferruginous or argillaceous, accompanies, on both sides, the Grampian chain of mountains, as it does that of the Alps. It sometimes, as Faujas has observed, even contains green porphyry, and green trap, and thus approaches to the famous universal bricia of Egypt. But these Scotish rocks have only a slight resemblance to the pudding-stone of England, as shall presently be shown.

Brard is also mistaken when he asserts that the paste is not fine; for, in the choicest specimens, it is of surprising fineness and delicacy.

Kollanite peculiar to England.

It would appear that this beautiful stone is quite unknown in other regions. Wallerius has described it as a rock, composed of various flints, and England is the only country he mentions*; for those of Rennes, in Normandy, are, as Patrin has shown, only spotted jaspers. Gmelin, in the last edition of Linnæus, has described pudding-stone as consisting of fragments of petrosilex (hornstein) and quartz, cemented by jasper. He says that it is found in England, and also upon the Rhine and in Bohemia, assuming an exquisite polish, being variegated, but the jasper generally of a brownish red; and is used for vases, and various kinds of ornaments. His description may apply to that of the Rhine, as containing kernels of reddish brown jasper, and that of Bohemia; but is quite foreign to the English pudding-stone.

Mr. Kirwan, disgusted with the vulgar name of pudding-stone, derived from the resemblance

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* i. 444.

languages, is inclined to prefer the Latin
ilite of similar import; but the Greek Kol-
te is preferable, the Latin having passed into
dramatic *farce*, which ekes out the enter-
ment like the old Roman *farcimens*, or pud-
gs. He quotes the miners' journal, published
German, for a mountain of farcilite or pud-
g-stone, in Siberia, near a rivulet called Tulat,
sisting of rounded fragments of jasper, chal-
ony, carnelian, and beryl, in a quartzy ce-
t†. This he considers as primitive; but
ng the secondary rocks, quotes the same
age, only omitting the beryl, which indeed
ns foreign to such a substance. Even this
scarcely rival the English pudding-stone in
uty and variety; and, if it consists of round-
r rolled fragments, must be of quite a differ-
nature, as shall presently be explained.

he errors of foreign writers, concerning this
ular and beautiful production of England,

will appear the less surprising when we con the following description, just published by learned Dr. Kidd, professor of chemistry in University of Oxford, in his account of wha calls pebble-stone*.

Kidd's account.

" This term is applicable to a numerous of rocks, &c. consisting of pebbles of va sizes and colours; which are irregularly nected together, either with or without an in mediate substance; and it is presumed that cemented particles are pebbles, or have acqu their rounded form by attrition, from their form smoothness.

" One of the most striking varieties of peb stone very commonly occurs scattered in l masses over the vale of Berkshire; it consis numerous oval pebbles, of reddish black very much resembling raisins when swelle boiling, cemented together by means of i rated sand, of a brownish white colour. whole appearance of the mass has given ris the term plumb-pudding-stone, in this coun and the resemblance that gave rise to the is so remarkable, that it cannot fail to strike mind upon the first view. The term has very generally adopted by foreign mineralog curs in rolled fragments in the bed of the Eske, near Rosslyn Castle: it consists of numerous differently coloured particles, some resembling red jasper, very compactly aggregated without any intermediate substance."

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* Outlines of Mineralogy, 1809. App. p. 21.

This last may either be a spotted jasper, or a jasper bricia.

Accompanies chalk.

The coarse pudding-stone accompanies at intervals the vast chalk stratum of England, whose undulating outline, from S. W. to N. E. may be computed to about 600 miles. This coarse pudding-stone consists of common flint pebbles, sometimes united by an argillaceous cement, sometimes by a ferruginous, at others by an arenaceous rendered coherent by oxyd of iron. The red gravel which affords such an elegant contrast with verdure, and is well known for its binding or coherent quality, approaches nearly to the latter kind; and masses of such pudding-stone are frequent in gravel-pits, even in the neighbourhood of London. A large mass may be seen in the lane, which ascends from Kentish Town to Kenwood, to use the orthography of Lord Mansfield, derived from its *ken*, or wide prospect.

But the precious kind, which has acquired such celebrity all over Europe, for its beauty, variety, and pleasing accidents, not observable in any other rock, seems confined to the district of Hertfordshire above mentioned.

If the term pudding-stone be restricted to what the Germans would call an agglomerated substance, it may even be doubted whether it be properly applied in the present instance; for it is not only clear, as Patrin has remarked, that the pebbles never have been rolled; but, from an accurate and minute examination, that the whole is an instantaneous composition, a kind of disturbed crystallisation, like granular quartz; or, as in the stones called glandulites by Saussure, as containing nodules of a finer or coarser grain. It would seem that an intrusion of iron and clay, or what is called jasper, has imparted this peculiar appearance, as iron often inclines to the pisiform and fabiform. Or it may be that in a siliceous sediment the iron asserted its predominance and affinities, to assume these singular and beautiful forms*. But geologists might compose whole treatises on this rock alone; which may be as important towards a theory of the earth, as Saussure found the noted pudding-stone of the

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* On the influence of iron in such formations, see Collini's ingenious little work on the Agates of Oberstein. Manheim, 1776, 12mo. p. 126, seq.

Alps, whose vertical position led to his theory of *refoulements*.

A shell of the cockle kind, as already mentioned, has in one rare and solitary instance been observed in one of the pebbles; and in another, imbedded in the cement of the stone; which might, in the language of Werner, indicate that it is a transitive, if not a secondary rock. But this would not argue against its coetaneous formation, any more than the shells found in jasper, and many siliceous substances.

The varieties of this curious rock are almost infinite; and it is diversified with almost every shade of colour, except perhaps pure blue and green, the former of which does not occur even in the finest jaspers; but the latter, which is common in that substance, may probably be discovered when persons of real skill observe the sites of this remarkable rock*. Agate only presents single beautiful pebbles, of a more fine and waxy appearance, and often with more outlines; but here numerous pebbles display such various accidents, that in a large polished slab no two would be found exactly alike. Some have the concentric zones of agate, while others are spotted in infinite variety; and others, though rarely, are unicoloured. The beautiful marble bricia of Aix seems of a similar instantaneous formation, and approaches the nearest in point of variety, but is far inferior in tints and polish. Nor can a comparison be instituted with others the most beautiful amongst the rocks; such as blue and green granite, serpentine, miagite, niolite, corsilite, jasper, or even lazulite, which only present a few colours, and little variety in the texture; while here the colours and variety are infinite, and accompanied by the constant discovery of minute beauties and accidents.

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* I am since informed, from undoubted authority, that the green exists.

As not only foreigners, but even our own writers, seem strangers to the varieties of this stone, it may be proper to specify a few.

1. A Kollanite of grey pebbles in a grey cement, the pebbles being sometimes lighter, sometimes darker than the gluten, which is purely siliceous, and of a more shining or unctuous lustre than the nodules. This is the simplest appearance of the substance, and never esteemed worthy to be polished.

2. Nodules of a blackish grey, with some of transparent yellow, imbedded in a fawn-colour cement; consisting either of granular quartz, or

rather, as would seem, of minute sand, penetrated with siliceous liquor or pure quartz.

3. Little dark grey nodules, in a lighter cement, of a yellowish white.

4. A fawn-colour cement, in some places inclining to white, in others tinged with red, and studded with chalite of bluish grey, pale brown, lead colour, all inclosed in black zones, with one large nodule of a fine light lilac spotted with white, surrounded by a broad zone of yellow, which is followed as usual by an outline of black.

5. A slab, polished on both sides, of six inches square, containing great varieties of brown and yellow chalite, often with zones or tinges of lilac, purple, and a faint olive green. Many are spotted, with various tints, while others have numerous zones, like agate. The whole in a cement of coarse sand, of the same nature, agglutinated by transparent quartz, so that the substances appear as if seen through glass. A large pebble, of three inches by two, presents a singular accident; a large portion of the cement appearing in its centre, in such a manner as to leave no doubt that both were liquid at the same time, or must have crystallised together. The white pebbles have more the waxy appearance of chalcedony than of flint.

6. A detached large pebble, with a small adherent portion of the real kollanite, or precious pudding-stone. This beautiful pebble, which rivals or exceeds the finest jasp-agate, is encircled with a brown zone, followed by one of crimson, the middle of a fine variegated brown, sometimes inclining to yellow, bearing near the centre a spot about half an inch in diameter, of a bright orange inclining to scarlet. Detached pebbles, agatised with red and white, and with other beautiful accidents, are sometimes found on Hampstead Heath, and many other places. They are quite different from rolled pebbles, and are often of a flattened, sometimes a kidney form, like those in the kollanite. Their exterior appearance is of a brownish black, with little lineal indentations, as if encrusted. They are called by the lapidaries English pebbles, to distinguish them from what they call Scotish pebbles, which are generally of an impure agate.

7. Pebbles of various tints, but chiefly yellow and brown, in a whitish cement. The singularity of this specimen, which is about 5 inches by 3, is, that a little stream, as it were, of a light brown cement, and about an inch in breadth, runs down the middle, bending by the side of a very large pebble. In this stream the pebbles are all parallel with its direction, as if conveyed

by it, while those on either side are in perpendicular or contrary directions.

8. A specimen, about two inches and a half by two, containing about thirty small pebbles, of the most beautiful tints of red, black, brown, white, and cream colour, mottled and zoned in every conceivable form, in a granular transparent cement, which however inclining to pale red, affords not the strong contrast which a fawn-colour would have produced.

9. A piece, about four inches by three, presenting on a fawn-colour ground only ten or twelve pebbles, of the middle size; one of the purest uniform carnelian, with the usual black zone, and another of a fine purple red, or wine colour; while the others, chiefly red, are variously agatised and mottled. A singular accident in this beautiful specimen is, that a large red nodule is split in various directions, yet the fragments perfectly preserve their position, the chief rents being accurately filled by the fawn-coloured cement.

10. A mass, about eight inches in diameter. In the heart of a yellowish brown pebble, with a broad black border, and about three-fourths of an inch in diameter, is the fair impression of a little chamite, about a quarter of an inch in diameter.

In this piece may also be observed a very large pebble, split in two, but not displaced, the crack being filled by the cement, which is of a dull white, or light grey colour. A pebble, with a portion of the cement in the centre, and every where inclosed by the substance of the pebble. Another, with the same circumstances. One pebble, with a cavity containing small quartz crystals. A pebble, in the state of indurated clay, and easily cut with a knife, being enveloped, but not penetrated, by the siliceous matter.

11. Very small delicate pebbles, of a bluish grey, in a straw-coloured cement.

12. Cement, half red, half yellow, with dark pebbles.

13. Yellow and red pebbles, in a cement of a whitish grey; but tinged with a fine red on the side of some pebbles, and with yellow near others, as if the pebbles had yielded a part of their colour when the cement was introduced.

14. Pebbles of white quartz, in a deep red cement.

15. A beautiful piece, found in the ruinous part of the abbey of St. Albans. Cement grey, with delicate tinges of red and yellow. Of the larger pebbles, one is yellow, with spots of red; others yellow, with zones of white chalite, and

small lines of purple; and one may be styled agate, or chalcedony, being white delicately tinctured with red and yellow.

16. Fine red pebbles, in a cement of a darker red. The contrast is not however sufficiently strong; and the lapidaries in this case say, that the pudding has too much wine.

17. Dark grey and black pebbles, in a cement of a delicate dove-colour.

18. Brown, yellow, and red pebbles, in a cement of an ash grey, which only admits a dull earthy polish, while the pebbles are of great brightness.

19. Very small pebbles, of almost every colour, in a bright yellow cement. Exquisitely beautiful.

20. A pebble, about two and a half inches by one and a half, which is not only a pebble but a kollanite, as it contains distinct agatised pebbles*.

When the original sites of this stone are examined by persons of real skill, it is probable that a vast number of interesting varieties will be discovered. Meanwhile it is hoped the reader will not blame some degree of prolixity concerning this singular substance, which has never been carefully examined, and concerning which so many errors have been propagated both at home and abroad.

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* Those only are described which are in the author's collection, or which he has himself seen. The rare green probably contains green pebbles in a yellow cement.

NOME IX. TOPAZ ROCK.

This beautiful anomaly is hitherto only known to exist in Saxony; and Mr. Jameson's description shall be copied, as it is probably the most authentic.

"1. The remaining primitive rocks we have now to describe, are less important than those we have already described, because they occur less abundantly, and not so widely extended. One of the most remarkable of these is the topaz rock, which is not only remarkable on account of its constituent parts, but also its structure. It is composed of quartz, topaz, schorl, and a small portion of lithomarge. The quartz is fine granular; the schorl thin prismatic; the topaz usually coarse and fine granular, and has commonly a grey colour, which is to be attended to in its discrimination. These three fossils are disposed in layers, and thus form a slaty structure; but this slaty structure occurs only in the small; for these layers are collected into particular large granular masses, so that the topaz rock appears large granular in the great: a kind of structure which is termed slaty granular. The drusy cavities, that sometimes occur between these concretions, frequently contain regular crystallised topaz and quartz; sometimes also schorl and lithomarge, of the same colour as the topaz.

"2. Its stratification is uncommonly distinct.

"3. Its geognostic position has not been hitherto satisfactorily ascertained. It appears to lie on gneiss, and under clay slate.

"4. It is a very rare rock, having been hitherto found only in one place in Germany, near the town of Auerbach, in the Saxon part of Voigtland, where it forms a mountain mass of considerable extent, and is there known by the name of Schneckenstein. A rock, composed of topaz, beryl, quartz, and lithomarge, occurs in the mountain of Odontschelon, and in the neighbourhood of Mursinsk, in Siberia, which resembles topaz rock, and is suspected to be the same with that of Auerbach. The schorl-rock of Cornwall is probably very intimately connected with topaz rock."*

It is truly surprising, that what are called the geognostic relations of so remarkable a rock should not have been explained, especially as it stands in Saxony, the very focus of mineralogic knowledge. Henkel, as quoted by Patrin, says that the mountain or hill called Schneckenberg is near the valley of Tanneberg. The slope of the mountain is gentle; but from the summit rises, like a tower, the topaz rock, being about eighty feet in height, and three times as broad. But we are still to learn the composition of the adjacent hills[*].

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* Jameson's Min. iii. 141.

NOME X. JACINT ROCK.

A rock, which contains jacints, and which is itself composed of large white, greenish, and yellowish grains, consisting of quartz and of jacint, so that it may be called jacint rock[†].

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[*] Among the ejections of Vesuvius there occurs what may be called Chrysolite rock, that gem even sometimes serving as a base; but these fragments, placed by Gmelin among the rocks, may perhaps be mere vein-stones, or may occur in small quantities. Perhaps rocks of Corindon may be discovered. It was known to Woodward by the name of *Tella Corivindam*, and *Nello Coritindam*.

[†] Sauss. § 1903.

NOME XI. BERYL ROCK.

This was discovered in France, near Limoges, by le Lievre. It had been used in paving the highway, and is seldom of a good colour, being generally of a greyish white, though some specimens offer a tint of green. It is however rather a vein-stone, though found in large masses, as it runs through the middle of a vein of quartz in a granitic region*.

NOME XII. GARNET ROCK.

The red garnet, of which this beautiful rock is chiefly composed, contains from 20 to 41 parts of iron, according to analyses of Klaproth and Vauquelin. The green garnet is even sometimes fused as an ore of iron.

In his System of Mineralogy, Cronstedt regarded the garnet as entitled to a peculiar place in the rank of earths; a singularity which would seem to show that he had a distant view of the necessity of introducing the ferruginous or siderous among the other earths.

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* Faujas, Geologie, Paris 1809, vol. ii. part i. p. 208. See particularly Journal des Mines, v. 641. The analysis of Vauquelin found the same ingredients as in the emerald.

This curious rock seems unknown in any system of mineralogy, except Mr. Kirwan's, who says, "Garnet-rock of Karsten, found by him near Winneburg: it consists of amorphous garnet, in which trap, quartz, calcareous spar, and a very small quantity of blackish brown mica are found."*

But the garnet rock, recently discovered in Scotland, seems to consist of that matter minutely interspersed among siderite and felspar, with larger or smaller globules, or imperfect crystals of garnet. In some parts it seems to approach to slaty siderite, penetrated with garnet; as it is common for that schistus to contain garnets.

The surface is brown from the decomposition of iron; and the garnets are of a coarse texture, and irregular form.

STRUCTURE I.

Amorphous garnet rock, containing trap, quartz, calcareous spar, and mica, from Winneburg.

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* Min. i. 368. The Scotish may be the rock with grains of garnet from Sweden, Norway, &c. Linn. à Gmelin, 223. The *Saxum Molare Granaticum, colore rubente,* of Wallerius, from Norberke in Sweden.

STRUCTURE II.

Garnet rock, interspersed with siderite, felspar, and spangles of brown mica, from Portsoy in Scotland.

It seems essential to this rock that the garnet matter should be dispersed throughout; otherwise gigantic and common garnets are sometimes so closely mingled in mica slate, that the rock might fall under this denomination.

The garnet trap of Saussure, § 2258, of a brownish green colour, composed of a mixture of particles of steatite, fibrous hornblende, and mica, including many little garnets of a dull red?

NOME XIII. SHORL ROCK.

This rock is chiefly composed of the common black shorl*, the black tourmaline of Haüy, which, according to Klaproth, contains 22 parts of iron. It is common in granite, gneiss, and other primitive rocks; but is sometimes found to form a rock by itself, or mixed with quartz. It must not be confounded with the shorl *en masse* of Saussure, and other French mineralogists, which is siderite.

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* The word is original, and not derived from the town of Shorlau, as appears from the term *Shirl*, used by the Cornish miners in the same sense.

Shorl rock is not uncommon in Cornwall; the substance being generally, if not always, in small crystals, sometimes disposed in transverse radiations.

STRUCTURE I. ENTIRE.

Shorl rock in small crystals from Cornwall.

In very small crystals, elegantly fasciated in various directions, from the same county.

STRUCTURE II. MINGLED.

Shorl rock mingled with quartz, from Cornwall.

Dr. Kidd informs us that Roche Castle, near Bodmin, Cornwall, stands on a rock of this description[*].

NOME XIV. ACTINOTE ROCK.

Saussure describes, § 2281, entire rocks composed of grey delphinite; a kind of glassy actinote.

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[*] Outlines, i. 235.

NOME XV. MARBLE OF MAJORCA.

This rock is of a singular and anomalous structure, as the shape of the spots, or concretions, resembles that of almonds. It is black and white, and takes a very fine polish. The natives call it *amandrado**. It is found near Alaro, in the island of Majorca.

NOME XVI. MARBLE OF CAMPAN.

This marble, so well known in France, is found in the Pyrenees, not far from Bagneres. It is either red or green; and both colours even occur in a small specimen; but it is greatly contaminated with argil, as before mentioned. It is ranked among the anomalous rocks, because it often presents a singular structure, which may be called guttular, being disposed in oblong drops like icicles. These uncommon forms sometimes become important in a geological point of view. Ramond observed another marble in that vicinity, analogous to that of Campan, " that is to say, with a white base, veined with red and green by steatitic clays; it contains a number of conical nodules, in which the different substances which compose it are rolled in a spiral form, and represent so many little distinct whirlpools, as independent of one another, as different from the flexions of the layers which contain them."*

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* Laborde's Spain, iii. 448.

HYPONOME I.

Red guttular marble of Campan.

HYPONOME II.

Green.

NOME XVII. PHOSPHORITE.

This rock is reported by some to form hills, and by others only thick strata, in the province of Estremadura, in Spain. It is said somewhat to resemble curved laminar barytes; and is of a yellowish white colour, often spotted with yellowish grey. It is a combination of lime, and phosphoric acid, the latter amounting to 34. It is rather soft, and brittle, and translucent on the edges.

Brochant says that its site is at Logrosan near

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* Ramond, Voy. au Mont Perdu, p. 99.

Truxillo, in beds mingled with quartz, and in such abundance as to form a hill. It was known for a long time to the inhabitants by its property of yielding a phosphoric light. In 1788, Proust first indicated its nature, in the *Journal de Physique*[*].

NOME XVIII. GLOBULAR ROCK.

This anomaly was discovered by Saussure, in a hill not far from Hyeres, in the South of France. As his important work has never been translated, an extract may be satisfactory.

" On my ascent I observed, in the calcareous rock of the mountain, a hemisphere of 15 or 18 inches diameter, entirely composed of calcareous spar, disposed in concentric layers, and each of these layers formed by an assemblage of needles, converging towards the centre of the mass. I at first thought it was accidental; but, as I proceeded, I saw with much surprise that the whole mountain, to its very summit, is composed of balls of spar, whose structure is nearly the same. Their bulk varies: the largest being two or three feet in diameter; the smallest, two or three inches: some are seen also of an elongated form; but the layers are always concentric, and composed of parts converging to the centre, or towards the axis of the mass. Sometimes these layers, although concentric, are undulating or festooned. These balls, both the large and small, often intermix and arrange themselves in strange forms; and nevertheless the whole is disposed in beds pretty regular, a little inclined, rising to the north or north-east.

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[*] Min. i. 585.

"The spar which forms these balls, is of *honey-yellow*, or translucid yellowish white; and the grain is very brilliant. The interstices of the balls are filled with a less dense matter, often cellular and of a coarser tissue, but the nature of which is essentially the same.

"One cannot but observe in these forms the work of crystallisation; stalactites and geods are seen to present similar structures; but an entire mountain, composed of an assemblage of these crystallisations, is a most extraordinary phenomenon."*

* Sauss. § 1478.

NOME XIX. BARYTIC ROCK.

Mr. Kirwan informs us, that Hoepfner discovered a whole mountain in Swisserland, composed of quartz, barytes, and mica partly compounded with shorl. Mr. Kirwan calls this kind of barytes, *baroselenite*; because it resembles selenite, or gypsum crystallised in plates. It is the plane, laminar, heavy spar of Werner, in which the most common colours are white and red. In the curious rock here mentioned, the barytes was of a flesh red colour; but it must not be forgotten that Hoepfner's observations and analyses are not of the first authority; and his barytes may be found to be a felspar.

In the mineralogy of the department of the Loire, there is the following account of a singular rock near Ambierle, a village near three leagues N. W. of Roanne*.

"There is there seen a rock, situated between two little valleys, on the eastern side of the hill. This rock, which separates these two valleys, is a disordered mass, composed of fluor and barytes, sometimes mixed, sometimes in separate and distinct parts, but always in intimate contact, and traversed by some veins of quartz. The fluor is of various colours: green, violet, and reddish; yielding much phosphorescence when thrown on hot iron, as well as a spathose acid gas, very acrid and corrosive, when it is heated with vitriolic acid. The barytes is white, with a slight tinge of red, very pure, and disposed in large plates. It is sometimes crossed with veins of a beautiful pitch-stone, of a deep yellow, a little transparent, but sometimes opake, and resembling yellow resin.

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* Journal des Mines, iv. 127, by Passinges.

"The texture of this pitch-stone is rather loose, and it seldom strikes fire with steel; but in its fracture it shows the conchoidal form, as well as the convolved streaks of silex; while some, in a state of decomposition, leave a lilac coloured earth, which cleaves to the tongue. It appears that it is coloured by iron, for there appear, in some parts of this stone, grains of that metal, which have given more intensity to the colour of the pitch-stone in the adjacent parts.

"On examining some of the fluors, it may be observed that there have been successively deposited new layers of the same fluor, and of quartz of different colours, till the cavity, in which the first crystals were formed, was filled up. This frequent mixture of different substances forms veins in zigzag; because they followed in their deposition the unequal angles of the cubes, which served them as a base. Some of these fluors have shown indications of the oxyd of cobalt, others of manganese in stalagmites. Only one piece of fluor has been found traversed by the same pitch-stone: there are also found, but rarely, small cavities which contain little crystals of fluor, barytes, and quartz.

"It may be judged by the quantity of fragments scattered around this rock, and in the surrounding vineyards, that it has been of a far greater height, and that it has been injured and shattered from many causes, but especially the cultivation of the neighbouring vineyards; there are even large open slits, which show that it has been shaken. It has even been attempted to make mill-stones with the barytes, of which there are large masses, but the attempt did not succeed. All these fragments display much more quartz, mingled with the fluor and barytes, than the rock itself; which, nevertheless, may be said to form a kind of pudding-stone, as presenting adherent mixtures of various kinds.

"The environs of this remarkable hill show, in the hollow roads, veins of barytes amidst fluor. The rocks of the adjacent mountain are of primitive grey granite, consisting of felspar, quartz, and mica. It is rather soft, but is used for the supports and traverses of doors and windows, resisting the air a considerable time. It is to be presumed that mines may be discovered in this district, though nothing in that way has been attempted. Some cubic pyrites, yellow or black on the surface, give no strong hope in that respect."

Some important rocks must now be considered, which are not only anomalous in their structure, as the preceding; but of which the whole mass forms a deviation from the usual order of nature. Such are, as above mentioned, the Saline, Bituminous, Sulphuric, and Iron Rocks.

NOME XX. SALINE ROCKS.

The most remarkable of these exist in Spain and Africa. The latter saline hill can only be said to have been observed; but those of Spain have been described by Bowles, in his natural history of that country*. The first is in Spanish Navarre, between Caparoso and the river Ebro, in a chain of hills which extend from east to west.

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* See the French translation, by Viscount Flavigny, Paris 1776. 8vo. p. 376, 406.

Of Navarre. "These hills," says he, "are composed of limestone mingled with gypsum; the chain extending more than two leagues. In the most elevated part is situated the village of Valtierra, on a slope towards the middle of which is found a mine of rock-salt. It may be about 400 paces long, and 80 wide. The salt is contained in a space of about five feet elevation.

"I examined," he adds, "with attention those beds of salt; I compared them with the layers of earth and gypsum in which it is imbedded; I found the outside layer to be composed of gypsum; and immediately afterwards I met with two inches of white salt, succeeded by two inches of stony salt and a layer of earth. I found others alternately composed of earth and salt, to the very bottom of the mine, which is of gypsum, undulated like the other layers. The layers of saline rock are of a dusky blue, those of salt are white.

"This mine," adds Bowles, "is considerably elevated above the sea; for you ascend continually all the way from Bayonne."

The second hill is far more memorable, and is even very extraordinary: it is that of Cardona, in Catalonia, 16 leagues to the N. W. of Barcelona, and a few leagues from the Pyrenees.

Of Cardona. "The village of Cardona," says he, "is situated at the foot of a rock of salt, which from the side of the river Cardonere, seems nearly mural. This rock is a block of massive salt, which rises from the earth about 4 or 500 feet, without crevices, chasms, or layers: no gypsum is found near it. This block is about a league in circumference; and its elevation is equal with that of the surrounding mountains; as its depth is not known, it is impossible to say on what it rests.

"In general, the salt from the top to the bottom is white, though some parts are red; some is also found of a fine blue.

"This prodigious mountain of salt, destitute of all other matter, is the only one of its kind in Europe. I do not know," adds Bowles, "if it would be correct to affirm that it was formed by an evaporation of the sea; such a solution might not satisfy every one."

The salt mines of England are well known, but are not elevated above the ground. The same observation applies to the grand and celebrated mine of Wieliczka, in that part of the former kingdom of Poland called Galitz, once ceded to Austria. Smaller mines of salt are also found at Thorda, Dees, and Eperies, all in Hungary.

But the most remarkable mines of salt, after

Of Peru.

those in Spain and Africa, are in Peru; and are thus described by Ulloa, who says they are situated at the surprising height of 10 or 12,000 feet, on the grand chain of the Andes.

"The highest part of Peru," says Ulloa, "which seems to be a depot of minerals, has also mines of salt. It is found in hard blocks, and continuous like the rock. The exterior form of this salt strikes at first sight; for it resembles a stone of a dull violet colour, strewed with rays of jasper.

"These mines of salt are found nearly all over the country; and what is most worthy of remark, is its extreme hardness, its colour, and that it should be in those mountains equally as high as those which yield silver or mercury, which is certainly extraordinary."*

Mr. Kirwan has treated this subject with his usual mineralogic erudition.

Kirwan's account.

"Many mountains, entirely consisting of salt, have been discovered. The salt mountain of Cardona, in Valentia, is from 4 to 500 feet high, and about three miles in circumference. Bowles, 406. Fortis mentions several in Calabria, attended with some of gypsum. Several in the States of Algiers and Tunis are mentioned by Shaw, p.

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* Mem. i. 352.

229; and another in the province of Astrachan, 3 Buff. Min. 8vo. p. 371: the salt in this, however, contains a mixture of foreign ingredients, the nature of which has not been accurately determined. The salt of the mountain Jibbel Hadiffa is of a purplish colour, and bitter; but whether the bitterness proceeds from glauber, or muriated lime, or magnesia, or some two of them, is not known; but that it proceeds from one or other of them is certain, as this bitterness is easily mashed out. In the province of Yakoutz, in Siberia, near the river Kaptindei, there is a mountain of salt 180 feet high, and 120 in length; but at two-thirds of its height it is covered with a stratum of red clay, which reaches to its summit. 1 Gmelin Voy. 342, cited by Macquart, 82.

"Patrin suspects that many granitic mountains contain salt; which, he thinks, has been the cause of destruction of many of them, and at this day promotes the decomposition of many that still exist; hence he derives the saliniferous, sandy plains of Siberia, 4 Nev. Nord. Betr, 167, 174: but it more commonly, at least, proceeds from salt springs beneath the sand. See 1 Herman *Uber die Uralisch Erze Gebirge*, 36."*

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* Kirwan Geol. Ess. 373. For the Salt Mountains of Persia, see Olearius.

It must not be forgotten that a mountain of salt has recently been discovered on the western side of the river Missouri, in North America.

In the salt mines of England, Pictet observed a singular structure, somewhat resembling that of basaltic columns. In those of Poland, a similar polygonal structure has also been observed; but was supposed to arise from large globules compressed on all sides by others. Further considerations on rock-salt may be found in many mineralogical treatises; and are scarcely requisite in a work of this nature*.

HYPONOME I.

Entire saline rock, blue, red, white.

Micronome 1. Mixed with gypsum.

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* The numerous and prodigious rocks of ice in the polar regions,

NOME XXI. BITUMINOUS ROCKS.

The chief bituminous substances are naphtha, or pure rock oil, as fluid and transparent as water; petrol, which is less fluid and pure, when it is yet more impure it becomes mineral tar. Of mineral pitch there are three diversities: Maltha, of a brownish colour and earthy construction; Asphalt, pure and black; and the *elastic*, or mineral Caoutchou.

All the bitumens belong more strictly to the province of chemists, who now arrange them after the vegetable substances, from which, like coal, they all seem to be derived.

Gangarts.

They are most commonly found in the proximity of that mineral, and in its most usual attendant rocks, limestone and sandstone. In Siberia, *bitumen* has even been observed in balls of chalcedony. It sometimes also appears in veins, that traverse that argillaceous glutenite called grauwack; and in veins of calcareous spar in basalton, or the transitive grunstein of Werner. The asphalt occurs in mineral veins, like the caoutchou. The chief bituminous rocks, however, are limestone and sandstone; the former being generally black, as at Sefeld, in Tyrol.

The grandest appearance of that nature is at Baku, on the western side of the Caspian Sea; whence it is supposed that this substance was brought to Constantinople, where it formed the chief ingredient of the noted composition called the Grecian fire; which, burning with increased intensity under water, became a most formidable instrument against an inimical fleet. From the description given by Hanway, it would appear that the rock is limestone. His account of this singular phenomenon deserves to be here repeated.

Naptha of Baku.

"The earth round this place, for above two miles, has this surprising property, that, by taking up two or three inches of the surface, and applying a live coal, the part which is so uncovered immediately takes fire, almost before the coal touches the earth: the flame makes the soil hot, but does not consume it, nor affect what is near it with any degree of heat. Any quantity of this earth carried to another place, does not produce this effect. Not long since, eight horses were consumed by this fire, being under a roof where the surface of the ground was turned up, and by some accident took flame.

"If a cane or tube, even of paper, be set about two inches in the ground, confined and close with the earth below, and the top of it touched with a live coal, and blown upon, immediately a flame issues, without hurting either the cane or paper, provided the edges be covered with clay; and this method they use for light in their houses, which have only the earth for the floor: three or four of these lighted canes will boil water in a pot, and thus they dress their victuals. The flame may be extinguished in the same manner as that of spirits of wine. The ground is dry and stony; and the more stony any particular part is, the stronger and clearer is the flame; it smells sulphureous, like naptha, but not very offensive.

"Lime is burnt to great perfection by means of this phenomenon; the flame communicating itself to any distance, where the earth is uncovered to receive it. The stones must be laid on one another, and in three days the lime is completed. Near this place brimstone is dug, and naptha springs are found.

"The chief place for the black or dark grey naptha, is the small island Wetoy, now uninhabited, except at such times as they take naptha from thence. The Persians load it in bulk in their wretched vessels, so that sometimes the sea is covered with it for leagues together. When the weather is thick and hazy, the springs boil up the higher; and the naptha often takes fire on the surface of the earth, and runs in a flame into the sea in great quantities, to a distance almost incredible. In clear weather the springs do not boil up above two or three feet; in boiling over, this oily substance makes so strong a consistency, as by degrees almost to close the mouth of the spring; sometimes it is quite closed, and forms hillocks that look as black as pitch; but the spring which is resisted in one place, breaks out in another. Some of the springs, which have not been long opened, form a mouth of 8 or 10 feet diameter.

"The people carry the naptha, by troughs, into pits or reservoirs; drawing it off from one to another, leaving in the first reservoir the water, or the heavier part with which it is mixed when it issues from the spring. It is unpleasant to the smell, and used mostly amongst the poorer sort of the Persians, and other neighbouring people, as we use oil in lamps, or to boil their victuals; but it communicates a disagreeable taste. They find it burn best with a small mixture of ashes: as they find it in great abundance, every family is well supplied. They keep it at a small distance from their houses, in earthen vessels, under ground, to prevent any accident by fire, of which it is extremely susceptible.

"There is also a white naptha on the peninsula of Apchèron, of a much thinner consistency; but this is found only in small quantities. The Russians drink it both as a cordial and a medicine, but it does not intoxicate: if taken internally, it is said to be good for the stone, as also for disorders of the breast, and in venereal cases, and sore heads; to both the last the Persians are very subject. Externally applied, it is of great use in scorbutic pains, gouts, cramps, &c.; but it must be put to the part affected only; it penetrates instantaneously into the blood, and is apt for a short time to create great pain. It has also the property of spirits of wine, to take out greasy spots in silks or woollens; but the remedy is worse than the disease, for it leaves an abominable odour. They say it is carried into India as a great rarity; and, being prepared as a japan, is the most beautiful and lasting of any that has yet been found. Not far from hence are also springs of hot water, which boil up in the same manner as the naptha, and very thick, being impregnated with a blue clay; but it soon clarifies. Bathing in this warm water is found to strengthen and procure a good appetite, especially if a small quantity is also drank."*

The justly celebrated Kempfer had visited these remarkable springs in the end of the seventeenth century; and Gmelin, in the eighteenth century, 1773, has added little to the account of Hanway, except that the soil is a coarse marl, mixed with sand, and effervescing with acids. There are many other wells in an adjoining peninsula; and the revenue arising from this uncommon product, to the khan of Baku, was computed at forty thousand rubles.

Werner rather doubts the existence of pure and limpid rock oil, and unites naptha with petrol: the purer kind indeed seems to occur only in small quantities. The mineral tar of Colebrook Dale is obtained from a sandstone: and Williams has observed many bituminous rocks in Scotland. Bituminous shale and marl are not uncommon; but the whole subject requires and deserves further illustration.

HYPONOME *I.*

Limestone with naptha, or with petrol.

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* Hanway's Travels, i. 263.

HYPONOME II.

Sandstone with mineral tar.

HYPONOME III.

Mumia or asphalt, in the rock, from Persia.

Micronome 1. Bituminous shale.

Micronome 2. Marl.

Micronome 3. Limestone with caoutchou.

NOME XXII. SULPHURIC ROCKS.

The pyritic rocks, as has been already explained, are generally arranged in the respective modes of the substances in which they are found; pyrites being, like mica, of almost universal occurrence, and nowise considered as altering even the structure of the stone.

Wernér has considered sulphur as natural, and volcanic; the latter being found in lava, or near volcanoes. That found in the other rocks, is here chiefly to be considered: and Mr. Jameson has well illustrated this subject.

" Natural sulphur commonly occurs in masses, in gypsum, limestone, and marl. Near Artern, it occurs along with honey-stone and bituminous wood.

" It is sometimes found in veins that traverse primitive rocks; in veins of copper pyrites, that traverse granite at Schwartzwald in Swabia, in Siberia, in the gold mines of Catherineburg, and in leadglance veins in the Altaian mountains.

" It occurs also in nests in limestone, in Ireland; in sandstone, at Budoshegy, in Transylvania; along with red manganese-ore, at Kapnik; and with red orpiment, at Felsobanya.

" Very lately, the celebrated and enterprising Prussian traveller, Von Humboldt, communicated to the National Institute of France, a note, in which he mentions his having discovered, in the province of Quito, between Alausi and Ticsan, a bed composed of sulphur and quartz, in a mountain of mica slate; and also great quantities of sulphur in primitive porphyry."*

HYPONOME I.

Porphyry with sulphur.

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* " Annales de Museum National, cahier 17." Jameson Min. ii. 40.

HYPONOME II.

Mica slate with the same.

HYPONOME III.

Limestone with sulphur.

HYPONOME IV.

Sandstone.

NOME XXIII. IRON HILLS.

In his curious work of physical geography, Bergman informs us that there is a mountain near Tornea, in Bothnia, entirely consisting of iron-ore. In Luleo Lapland, the mountain of Gellivar is one entire mass of rich iron-ore, of a *blackish blue* colour, extending like an irregular vein for more than a mile, and of a thickness from 3 to 400 fathoms. He also informs us that the two mountains of Kerunawara and of Lousowara, in Pitea Lapland, only separated by a small valley, are entirely composed of iron-ore. This iron, as he describes, is called virgin or native iron; to distinguish it from what were called mineralised, as being mixed with sulphur*.

This father of modern mineralogy has more minutely described the hill of Taberg, in Smoland, in the southern part of Sweden; which has been mentioned by Born, as being 400 feet in height, and about a league in circuit, in the midst of a sandy plain; and solely consisting of granular black iron, cemented by quartz into a solid mass, extremely compact and hard. Bergman's description follows.

Bergman's account of Taberg.

"Among the most singular mines of iron, may be reckoned that of Taberg, in Smoland: it extends from the N. N. W. to the S. S. E. rising gently on the northern side to a considerable height; then sinks a little, and again rises, forming at last a very high crest, and terminating in an abrupt cliff towards the river Mansarpa, above which its summit is elevated 420 feet to the S. E. and on the other side of the river is a corresponding height; to the E. and S. W. there is a succession of heights, equally separated from the mountain of Taberg by a river which runs through a valley a quarter of a mile long. Beyond the lake Wetter, in the environs of Jonkoping and of Taberg, as far as the district of

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* Journal des Mines, No. 16, p. 58, 23.

Oesbo, the soil is a movable sand. Near the cliff are large collections of ferruginous ore, without any intermixture of stones; some being several feet thick. They are placed in horizontal layers, separated by strata of earth, and ascend about three-fourths of this part of the mountain. The crest of Taberg, and probably the whole mountain, is filled with narrow parallel veins, which are generally vertical, following the direction of the mountain; the richest are seldom more than a quarter of an ell in thickness*, and are known in that part by the name of iron-bands *(Iaernbands):* they contain a blackish brown and shining ore, which yields thirty-two pounds and a half in the hundred weight. The common ore has a particular appearance: it seems smoked, and has no lustre; it gives 31 per cent. That which is called ribbon ore, or pied ore, has layers of white spar between its plates, and thus shows in the fracture alternate rays of white and black; it yields 21 per cent. The veins of this latter kind are exposed on the western declivity of the mountain. The effect which this enormous mass of ore presents, is well calculated to excite curiosity and wonder; though it is not the only example of the kind that nature offers to us."*

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* The Swedish ell is only two feet.

Patrin's remarks.

Patrin has observed on this description, that Taberg, far from being an irregular mass of ore, is on the contrary a mountain of a most regular structure; the arrects, or uprights†, having their planes parallel to its great axis, as is generally observed in primitive mountains.

The same able observer, who passed many years in Siberia, thus proceeds:

"The mines of iron in veins, which I observed in Siberia, in the Ural mountains, have a singular resemblance to those of Sweden.

"The two principal ones are those of Blagodat and of Keskanar, both upon the eastern side of the Uralian chain; the first thirty, and the other fifty, leagues to the north of Ekaterinburg.

Blagodat.

"Blagodat, like Taberg, is a mountain about 400 feet in height, in which the upright veins run from north to south, as the chain itself.

"The summit is almost entirely composed of ore, for an extent of 200 fathoms in length and

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* Ib. 57.

† These terms are hazarded, as already stated, to supply a defect in mineralogical language, lamented by Saussure and many other writers; the expressions of *vertical beds*, or *vertical layers*, being highly objectionable.

100 in breadth. The veins, which are several feet and even fathoms thick, are only separated by layers of schistus, and a kind of trap, which are scarcely so thick.

" The ore is of the black compact kind, much affected by the magnet; it yields 60 per cent. in fusion, and affords most excellent iron.

" There are annually extracted from this mountain two millions of pounds, or about seven hundred thousand quintals of ore.

Keskanar.

" The mountain of Keskanar has a similar structure; it is famous for the loadstones it has produced; blocks of 40 pounds weight of it have been found, which would carry two hundred weight; the small loadstones had in proportion a much greater strength; some have been seen which would carry twenty-five times their own weight. This magnet is mixed with a considerable quantity of greenish hornblende, which is dispersed through it in small nests some lines in diameter, and which is very glistening when the stone is polished.

" There are also loadstones in the mountain of Blagodat, and one of its summits is entirely composed of them, but they have a singular defect: when they are detached from the mountain, their poles multiply and intermingle, and they become useless.

"The same summit offers another singularity, which is, that it is crossed by a vein of copper. I have brought away a piece of this loadstone, which was found imbedded in this vein, and which is entirely covered with mountain blue and green. Since it has been in my collection amongst other loadstones, it has acquired a polarity rather more regular. It seems not impossible, with some pains, to re-establish that of the large pieces, that may be obtained from that mountain.

"The Altaian mountains are also in several places rich in iron-ore; but it is not wrought, on account of the distance.

"In that part of those mountains which the river Irtish crosses, when it quits the lake Zaïssan, I have seen, on the left bank of that river, perpendicular mountains more than six hundred feet in height, entirely composed of iron-ore. They are of ochre-coloured schistus, the thin layers of which are exactly perpendicular, and alternate with layers of compact iron-ore.

"Amongst the immense wrecks of these mountains, I saw several pieces of large grained loadstone, which contained nothing heterogenous, and with a complete metallic appearance: I brought away some specimens.

"It is not only in the frozen regions that nature has placed veins of iron-ore; and though they are there incomparably more frequent than elsewhere, they are nevertheless found in more temperate countries. Striking examples are seen in the mountain of Eisenertz, in Stiria; and in that of Rio, in the island of Elba.

"The mountain of Eisenertz is 3000 feet perpendicular; you there find almost every where abundance of iron-ore, especially at its summit: it is for the most part steel-ore; that is, carbonate of iron, or spathose iron-ore; and it is well known that this species of ore is never found but in veins."*

He then proceeds to state that the mine of Rio, in the isle of Elba, celebrated for this metal since the time of Virgil, may be said to be a mountain of iron. It now presents only disorder; the rock which separated the arrects having been decomposed, and seeming now to appear in the form of a white bole.

HYPONOME I. ENTIRE.

Iron rock.

HYPONOME II. MIXED.

With quartz.

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* Patrin Min. v. 18.

This subject cannot be quitted without the observation, that there seems a most manifest indication of MIND and DESIGN, or in other words of a great Creator, in the peculiar distribution of this metal in the northern parts of Europe; where He knew, to whom all times are present, that it would be necessary for the industry of the inhabitants. In like manner the increased thickness of the fur, or of the feathery down of animals, can scarcely be attributed to climate or chance: not to add another simple observation, but which does not seem to have been made, namely, the superior size and strength of the female, when compared with the male, solely among the birds of prey; as it was necessary that she should both protect and feed her voracious offspring.

G. Cooke fecit

Carpathian Mountains

DOMAIN X.

TRANSILIENT.

Distinct from Transitive.

THIS division includes the rocks which suddenly pass from one to another, so that specimens may sometimes even appear in cabinets; while the Transitive rocks commonly occur in a slow and scarcely visible progress; the term implying, in Werner's system, those intermediate between the Primitive and Secondary. The suddenness of the transition has given rise to the denomination, which implies that the substance has leaped, as it were, from one to another.

These rocks are extremely interesting in the study of Geology; and the learned reader will observe, that this treatise forms a gradual introduction to that sublime science, or rather study; for, even in the German sense of Geognosy, or knowledge of the shell of the earth, it can scarcely ever be supposed to arrive at the perfection of a science.

Distinct from Adherent.

Great care must be exerted not to confound the rocks which are merely adherent, or composite, with those that really graduate into another. Saussure, in speaking of a Russian traveller, says, that he would have boldly asserted that a roasting goose graduates into the spit. Thus some theorists have conceived that lime becomes flint, or flint graduates into lime, from the mere mixture of the particles near the line of their junction. The most proper and undoubted graduations occur only among the kindred rocks; and are generally a mere variation of the Mode or Structure; as the passage from granite to gneiss, or from granite to granitic porphyry. If the granite be surcharged with siderite, and its particles become very small, it may pass into the real basalt of the ancients; but can never become a basaltin interspersed with chrysolite or zeolite; and if the basaltin occur with granite, it must be merely adherent. Keralite may, by imbibing iron from the atmospheric air, or whatever cause, become jasper. Werner has observed, that wacken passes into clay on one hand, and basaltin on the other; which last again passes into basalton or grunstein. Many other undoubted transitions may be observed; but it will suffice to enumerate some of the most remarkable, leaving the others to time and accurate observation.

NOME I. SIDERITE AND BASALT.*

This transition may be observed in the Egyptian monuments, and is not uncommon in nature, when, in the German language, the massive hornblende rock passes into grunstein; or, in other words, becomes interspersed with small crystals of felspar; the common basalt of the ancients.

Siderite with basalt, from Egypt.

The same, from Mount Sinai.

The same, from the Alps.

NOME II. BASALTIN AND BASALT, OR BASALTON.

Of Meisner.

That is, in the German dialect, Basalt passing into Grunstein. Daubuisson observed this transition, in great perfection, at Mount Meisner, in Hessia, which rises like a colossus above the other heights of that country.† The mass is of shelly limestone; towards the top there are thin layers of sandstone and sand, followed by a bed of coal, in some places not less than 28 yards in thickness. Immediately upon this coal reposes a platform of basaltin, forming the level on the summit, which is about nine miles in length and about three broad. The basaltin exceeds a hundred yards in thickness.

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* The vague words *with* or *and* are used, because it cannot be positively affirmed which graduates into the other.

† Sur les basaltes de la Saxe, p. 59.

"The grunstein appears almost every where above the basalt, and in some places has the appearance of a beautiful granite; the grains of siderite being black or green, laminar, and as large as peas, while those of felspar are whitish. On the lower part of the platform, towards the west, there is a basalt in prisms; the most black, the most compact, and the most homogenous, as far as can be judged, that can well be observed. I here arranged the sequence of a dozen specimens, which presented a decrescent progression, with regard to the size of the grain, from the beautiful grunstein to the compact basalt, of which I have spoken; and to shun the objection that the specimens did not belong to the same continuous mass, I chose some in which the small grained grunstein was in the midst of the compact basalt; and they might be seen, so to speak, melting into each other." He then quotes the remarkable passage of Dolomieu in these terms: "I have seen many statues, mor-

Ancient basalt.

tars, sarcophages, made of black stones, which have all the characters attributed to the ancient basalts, and which have preserved that name; and I can say, with positive certainty, that none of them is volcanic." Dolomieu then proceeds to state that some of them are siderite, or massive hornblende; but the most common are a kind of granite, in which the siderite so predominates that the mass appears black, though it be associated with a white felspar, of which the grains are so small, or so interlaced with the scales of siderite, that it is difficult to discern them; especially as the felspar itself sometimes appears black, because it is transparent. He adds that it happens sometimes that a greater quantity of felspar imparts to the rock the appearance of a real granite; that is, as Daubuisson observes, a real grunstein.

This passage of Basaltin into the real Basalt of the ancients, is one of the most remarkable in Geology; and particularly interesting to the accurate and scientific observer. It seems, however, to be somewhat surprising that, while these substances are often found to coalesce, the Egyptians did not prefer the close grained and uniform basaltin to their coarser basalt. Siderite is also found in Mount Sinai, and perhaps in the eastern chain between Egypt and the Red Sea;

but as the ancient authors are unanimous that the basalt came from Abyssinia, it probably occurred under the appearance of columns, of too small a diameter to be employed in architecture or monuments. It is to be regretted that the mountains of Abyssinia have not been explored by any geologist, as the transcendent beauty of the emerald-green granite alone might invite a research into that interesting region.

NOME III. BASALTIN WITH PORPHYRY.

Basaltin being the base of porphyry, it is natural to expect many examples of this kind. Among others, near the village of Renaison, in the department of the Loire, there occur, after passing through fragments of granite, rocks of black trap, surmounted by porphyry of the same base, the transilience being clear and palpable. This porphyry is crowned by another porphyry, of a brownish grey; but in this the crystals of felspar are long, and thinly scattered (a porphyron); while the others are white, and frequent. The black porphyry, and even the grey, are harder than the trap.

The separation of the trap or basaltin from the porphyry is clearly marked by an undulating line, in a fragment which has been polished. The porphyry has taken a fine polish, while the basaltin remains dull. The polish of the porphyry has brought to light little crystals of schorl, or siderite, which could scarcely be discovered in the rude fragments.*

NOME IV. BASALTIN AND WACKEN.

Werner's account.

This transition has also been accurately traced by Werner himself. Speaking of the mountain of Scheibenberg, he says, "I have seen there, in a successive series of shades, the most perfect transition from clay to wacken, and from this to basalt (basaltin): these three substances are the produce of the same formation; that is to say, they are precipitates or sediments of the same dissolution, which becoming more and more quiet, has deposited the clay, then the wacken, and lastly the basalt."† This explanation depends upon Werner's theory, that the rocks were deposited by waters in different states of agitation or of tranquillity. It may be added, that there is much heat, or, in strict terms, caloric, in water itself, which would otherwise be in a state of ice, not to mention the heat developed by crystallisation; so that the agency of heat may be conceived as admitted even by the Neptunists.

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* Journ. des Mines, iv. 133.

† Daub. Basaltes, 58.

On the transition between Basaltin and Wacken, the remarks of Daubuisson may also be adduced. "We have already observed that basalt has great connexions with the argillaceous rock called wacken. Let us recollect those prisms, of which one of the extremities is a true basalt, while the other is an argillaceous substance, both being the evident produce of one effort; a circumstance which excludes every suspicion of a volcanic origin. This argillaceous wacken cannot be considered as arising from an eruption of mud; for between it and the basalt there is a most marked transition, there not existing even a line between them. Nor can it be said that this wacken is a decomposed lava; for at Scheibenberg, for example, the wacken passes to common clay, which degenerates into sand, and then into gravel; but a lava, when decomposed, does not produce gravel of quartz."[*] He adds in a note, that olivine, augite, &c. though common in the basalt, are not found in the wacken; so that the latter cannot be a de-

Basaltin not volcanic.

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[*] Daub. Basaltes, 73.

composition of the former. It must however in candour be added, that after his visit to Auvergne, where he was unexpectedly convinced of the volcanic nature of the products of that country*, Daubuisson hesitated concerning even the basalts of Saxony, and hinted to the author that they might be volcanic, but, as resting on the summits of hills, of an antiquity altogether inconceivable.

NOME V. WACKEN AND CLAY.

This transition has been before described.

NOME VI. JASPER AND KERALITE.

This transition, according to Patrin, is common in Siberia. The author has seen specimens, in the collection of that celebrated traveller, of keralite translucent on the edge, joined with opake jasper. The colours also correspond; but in the keralite they are pale. This transition seems to depend on the greater or smaller quantity of iron, a chief constituent in jasper.

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* See his papers in the Journal de Physique; and here Dom. I. Mode Basaltin.

HYPONOME I.

Massive.

HYPONOME II.

Schistose.

NOME VII. SLATE AND CHLORITE SLATE.

This is rather a scarce transition, the latter substance not being common. Slate also passes into mica slate; and sometimes into the massive substance described under the Mode Slate.

NOME VIII. FELSITE AND BASALTIN.

Dolomieu, in his able memoir on petrosilex or felsite, trap, and *roche de corne*, or magnesian basaltin, observes that they are the chief bases of lavas; and thus entered into his consideration, in forming a system of volcanic productions. He then speaks of the various transitions of his petrosilex or felsite*.

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* Journal de Physique, new series, vol. i. p. 250.

"Petrosilex, as I have already said, unites itself by gradual shades with all rocks, in whose composition some of the free earths enter, or compound particles which may assist in the formation of the masses which it chiefly constitutes. Combined with pure quartz, in which it seems to dissolve, it gradually assumes all the characters of quartzose rocks; by a progressive augmentation of talcous earth, it proceeds to unite itself to steatites and serpentines, forming in its progress a kind of fusible jad, which has not the weight of common jad: it acquires the earthy smell, as it approaches the *roche de corne;* the schistose tissue, in uniting with argillaceous schisti. But it is when it approximates traps, that the shades of its transitions are most insensible: and an infinity of rocks placed between the two, leave the greater uncertainty concerning the species in which they should be classed, as the composition is scarcely ever the same in all the parts of the same mass: one portion shall incline to trap, while the other is affected by the fire like petrosilex. The base of many porphyries is found in this intermediate situation; as well as most of the ancient grey and green basalts which come from Egypt, when it happens that the fineness of their paste no longer allows the distinct grains of felspar and greenish hornblende to be perceived, which are still visible in the greater number."

NOME IX. GRANITE AND BASALT.

This sometimes occurs in the Egyptian monuments. In Norway, and other primitive countries, veins of basaltin occur in granite; but it is a mere coherence, and there is not the smallest trace of transition.

NOME X. GRANITE WITH GNEISS.

This transition is one of the most common in primitive countries.

Red granite with red gneiss, from the Alps.

Grey granite with grey gneiss, from the same.

NOME XI. GRANITE AND GRANITIC PORPHYRY.

This is also a very common rock.

The passage from granite to granitic porphyry being one of the most remarkable and important, the following observations of Dolomieu will be found to merit particular attention*.

" During the great coagulation, to which the primitive mountains owe their construction, it seems that there have been substances, of which the concurrence, or too great abundance, has impeded or prevented the regular aggregation, in giving the paste a tenacity, in some manner fattening it, to make use of a term applied to mother-waters when they refuse to crystallise. Such are the particles of talc, and of argillaceous and magnesian earths when free. It seems that these earths, naturally unctuous, have prevented the other particles from assuming the places to which the laws of elective aggregation destined them, in causing them to slide on one another. I have pretty generally observed that the superabundance of magnesian earth chiefly acted upon the laminar texture of felspar, causing its loss, without depriving the felspar of the faculty of assuming the exterior forms of its usual crystallisation. This is perceived in those felspars, which constitute the large spots in green porphyry, called *serpentino antico*; and still more in the felspars, which mingled with green hornblende form the granites called Egyptian greens. It frequently happens that their compact fracture no longer presents any indication of a laminar texture, though they still affect the quadrangular prismatic form, which belongs to their mode of crystallisation.

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* Journal de Physique, new series, vol. i. 1794, p. 193.

"Just as in the *magma* of mother-waters, reduced to a state of paste by evaporation, there are particles which, escaping from the viscidity of the medium in which they are engaged, aggregate and form crystals, which are found buried in the mass: in the same manner, in these kinds of *magma* of the great precipitation, it is rare that some isolated crystals are not found among them; and which have acquired so much more bulk and regularity, as they have had more facility of aggregation. They are distinguished from the paste which contains them, by their form, their tissue, and almost always by their colours, brighter than that of the base. Thus are formed rocks called porphyries; and which, in reality, only differ from granites by this accident of aggregation*.

"The distinction established between granites and porphyries is proper for common use, it is necessary for artists; nevertheless the lithologist could not admit it in a strict sense, without exposing himself to an error, which might lead him to mistake the identity of the origin of these two rocks, and the analogy of their composition. The celebrated naturalist (M. de Saussure), who has furnished us with a great and important truth, by proving, by a thousand excellent observations, that *the parts of granite are contemporary, that they have all been formed in the same element, and by the same cause, and that the principle of this formation is crystallisation;* but who has thought he ought to make two separate genera of granites and porphyries, and who to distinguish them has said, *in granite there is no paste, which envelops the stony grains of which it is composed, while in porphyries, is seen a uniform base, or cement, in which the other stones are enclosed:* this naturalist, I say, by the progress of his researches, has soon himself found the insufficiency of these distinguishing characters, of

Granites.

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* This can only apply to granitic porphyries: and some other remarks must be pardoned, from the state of the science at that period.

which I have long combated the precision. Primitive mountains have often shown him, as well as myself, many rocks which have united the two modes of being, and which seemed to be intermediate species between real granites and real porphyries; and to point out the gradations by which nature passes from the formation of the one to the other. How many rocks have I not observed, which, by their polished surfaces, showed the texture attributed to porphyries, by distinct and isolated crystals, forming spots on a base apparently compact, and of a different colour; while their fracture represented grains of granite, by the scaly tissue of the substance which had appeared to be the paste, in which the other substances were enveloped; for granites have a granular appearance, not always by the detachment of the grains of each of the substances which compose them, but by the nature of the texture of the felspar, of which the plates cross each other when confusedly crystallised*: and in all compound rocks, the substance which is sufficiently abundant not to be divided by the rencounter of other small stones mixed with it, and for its parts to form a kind of continuity of mass, in surrounding the other substances, of which the grains are easily isolated, may be considered as the principal base of the rock, or as the cement which agglutinates the small stony bodies, of a different nature, concurring to the formation of the mass. Such are granites, where felspar alone often constitutes three-fourths, sometimes four-fifths of the mass; and if an abstraction of the sparry tissue is allowed, which depends on a rather more perfect aggregation, and of which it may be deprived without changing its nature, the granular appearance of the granite disappears, the felspar assumes *the aspect of a cement in which the other stones are enclosed*, and the rock acquires the conformation of porphyry, without the transition of the one to the other requiring any other condition. Nature often, as if she would demonstrate the identity of the two rocks, performs herself, in certain masses, this successive transformation of granite to porphyry, by taking away and returning at intervals its laminar tissue to the felspar; and she produces masses which, according to the expression of definitions, may be in part placed among granites, in part among the genus of porphyries. It is not even requisite that the felspar should entirely lose its texture; it is sufficient that it be in very small plates confusedly intermingled, and that it contains other crystals of the same nature, but larger and better marked, and a little distinct by their colour from the base in which they are contained. Thus there is often observed among the Egyptian monuments, at Rome, a rock whose base is a mixture of felspar and black hornblende, both in small grains, although still very apparent; in this kind of granitose paste are contained tolerably regular large crystals of white or red felspar, which form spots on the base of the rock, and which give it the greater appearance of a porphyry: as sometimes the abundance of hornblende renders the paste which contains these crystals almost entirely black*. The granites called the green of Egypt, composed of hornblende and felspar, become similar to a porphyry, if the proportion of hornblende ever so little exceeds that of the felspar; because then the crystals of the latter detach themselves from one another, and, by separating, form distinct white spots on the dull green base of the rock. The uncertainty of the characters of this rock has always embarrassed systematic nomenclators, they have varied in the name they have bestowed on it, and in the place they have assigned it.

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* "It is equally on account of their scaly tissue that sparry marbles, called *saline*, seem formed of large grains, adhering together by juxtaposition. They owe the appearance of it to a confused crystallisation, which interlaces the sparry plates; and they lose this granular aspect, to assume that of a compact and uniform mass, when they are deprived of this commencement of regular aggregation."

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* Dolomieu by no means excels in literary composition, his sentences being very tedious and complex. His long notes, which only distract the attention, are here thrown into the text.

"I have seen in the mountains of Tyrol, and especially in the large rolled pebbles in the plains of Verona, which have descended from them, a great quantity of those rocks which might be called porphido-granites, from the union of those two characters; but the most curious of this kind I have ever met with, are those of Corsica; of which, ten years since, I deposited a hundred specimens in the beautiful cabinet of Florence, under the direction of my illustrious friend Fontana.

"But it is not the granite of the earliest precipitation which possesses this identity of composition with porphyries; these primary granites, as I have said, are more quartzy than the others; the felspar is less abundant in them, and cannot represent a cement. The medium in which they were formed being purer than in later times, the particles differently constituted have been less interrupted in the choice of places, assigned them by the aggregative attraction; and if in a few of these granites some of those large spots are found, which, like placards, announce some change in the constitution of the rock, they are formed by kinds of knots, or large kernels of a globular figure; the substances appear, as it were, nodular, and disposed in concentric layers; it seems that they might be produced by a small whirling motion in the fluid where the rock has coagulated*; and they resemble those knots which are seen in alabaster, and other rocks produced by concretions, when the water which deposited them was agitated. Posterior granites are most often deprived of grains of pure quartz, or display smaller, and in less quantity. The argil predominates more in the whole mass; and the felspar does not appear in it of exactly the same nature, since it admits a larger portion of calcareous earth, which perhaps is not at all essential to the composition of the first.

"More than three-fourths of the antique granites of the monuments of Rome, are deprived of grains of quartz; among others, the beautiful reddish granite called *Rosato*, of which such immense columns and so many Egyptian monuments have been formed; and in which I have discovered a considerable number of small octaedral crystals of opake yellow jacinth. Often in these granites, mishapen crystals, or grains of cannot have on the surface of mountains, where the weather, and a thousand other causes of degradation, alter the hardest rocks. If I have acquired some knowledge of the nature of rocks, I owe it in a great measure to the comparisons that I have been able to make from the observations furnished by the monuments of Rome, with those which I collected in the mountains: and I cannot too much advise all naturalists, who travel in Italy, to pursue a regular course of lithology on those large masses, whose extraction is a proof of the industry and power of that ancient people who used them, and of which the beauty seems to assure a sort of pre-eminence to the eastern regions which furnished them: and this advantage which they possess over ours, is doubtless owing only to the scantiness of means that we have employed to find similar substances in our own mountains; thus how ridiculous our magnificence appears, when we compare it with that of the ancients! I have made a descriptive catalogue of all the monumental rocks of ancient Rome, which perhaps may not be uninteresting.

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* Owing perhaps to gases?

"It is besides easy to show that the bases of many porphyries are only disguised granites; and it is sufficient to take off the kind of mask which covers them, and which depends on the colouring substance, to behold with astonishment that this base judged to be uniform, is itself a stone composed of two distinct substances, which do not even always require the power of the lens to be observable. Taking, for example, a small piece of the base of antique red porphyry, and with a blow-pipe directing the flame of a taper on it, it becomes brown by the first blast of the fire; and then are easily perceived the small black and white grains, intermingled like those of granite; and continuing the heat to the fusion of the mass, the white semi-transparent frothy vitrification of the white grains indicates the felspar: the opake black glass produced by the others, announces the schorl; this, more fusible, melts the first, and often encloses small grains of felspar, before the fire has affected them, and then their glasses mingle. As to the proportion of the two substances, it differs; but although I have observed them alternately to take the predominance, the one over the other, in the different masses that I have essayed, I have nevertheless found that it was the felspar which most often predominated in the base of antique red porphyry."

He proceeds to observe, that what he calls the ancient green serpentine, from the Italian phraseology, and which is our green porphyry, presents in its base a superabundance of what he calls schorl; that is, the hornblende of the Germans, or siderite of the present work. In some porphyries, called by the Roman artists *Ubriagones*, the felspar appears, as it were, melted into the base, so as only to present spots of a different tint. It is now well known that the base of the porphyries is a trap, or basaltin; and Dolomieu has the merit of having perhaps first observed that it could not be a jasper, as it is easily fusible by the blow-pipe: but many of his observations will, in the present advanced state of the science, be pronounced to be inaccurate.

Granite and granitic porphyry, from Mount Sinai.

The same, from the Alps.

The same, from the Grampian mountains, in Scotland.

In general the Scotish granites are very irregular; and, in small fragments, often appear as granitels, consisting chiefly of felspar with little seams or particles of mica, while the quartz is often rare and distant.

NOME XII. GNEISS AND MICA SLATE.

This is also a common transition in primitive countries.

Gneiss and mica slate, from the Alps, &c.

NOME XIII. STEATITE AND ASBESTOS.

Steatite, in assuming a fibrous form, passes into asbestos. This transition is very uncommon. Saussure has described a rock of this kind; and Patrin has observed that it affords a remarkable example of the passage of one rock into another.

" This stone, which I received from M. Struve, is of a grey colour, sometimes inclining to yellow, sometimes to green. It greatly resembles asbestos; but the filaments are larger, softer, and more unctuous to the touch; while the fracture lengthwise presents long and large fibres, parallel among themselves, perpendicular to their bases, and irregularly prismatic. Some are straight, others a little bent; and they are sometimes three inches in length. Their lustre is little or none; and where it seems lively, and almost metallic, this effect is produced by a thin coating of talc, which covers the fibres of the stone.

"The cross fracture is extremely unequal and splintry, with a mixture of spangles of a different substance. This stone is translucent on the edges, to the thickness of four lines, and so soft as to be scratched with the nail, the streak being whitish and of some lustre: it faintly stains cloth with a grey line, is a little flexible, and pretty heavy. Under the blow-pipe it melts into a black globule, not exceeding the tenth part of a line.

"It is then evidently an intermediate kind between talc, steatite, and asbestos.

"The long fibres are intermingled with prismatic columns, striated lengthwise, white, laminar, very brilliant, but of which I do not know the nature. They are soft, translucent, and soluble in nitrous acid; but without effervescence, and in length of time. They do not crackle under the blow-pipe; and on charcoal turn brown without melting. They can only be melted on a point of sappare, into brown brilliant glass, without bubbles, and half transparent; the drop not exceeding the tenth part of a line. This stone is found at Weysler Stoude."*

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* Sauss. 1916.

NOME XIV. SHALE AND COAL.

The particles of shale sometimes pass into coal, or the reverse. But this may rather be regarded as an adherence. Sometimes the shale is marked with vegetable impressions, which likewise pass into the coal.

Coal is sometimes, however, found so impure as to be unfit for domestic purposes; and such mines are commonly abandoned. When in the mineralogic language it passes into slate, it is far from being a recommendation in the kitchen or in the parlour.

Impressions.

The passage of coal into bituminous shale, is the most interesting. The latter sometimes bears the impressions of fish; which never seem to be observable on the coal. But Mr. Jameson says that the fish themselves are generally converted into coal, sometimes the scales into copper-ore; bituminous shale being common in copper-mines. It is the slate-clay, *Schieferthon* of Werner, which generally accompanies coal, and presents vegetable impressions, chiefly of gigantic ferns and reeds now only found between the tropics. This substance is commonly soft; but is sometimes so hard as to resemble basanite.

The clay-slate of that author, *thonschiefer*, is our slate, simply so called by way of eminence, but a grand and primitive rock; while the other is understood to be of recent formation.

HYPONOME I.

Uniform.

HYPONOME II.

With impressions.

The following transitions are upon a larger and more various scale; but may be here subjoined, in order to throw more ample illustration upon a curious and intricate topic.

Saussure has minutely described a singular transition from granite to limeslate, which he observed not far from Courmayeur*.

"Travelling through these pasturages, the eyes always fixed on the primitive chain, I saw below this chain beds similar to slates, and leaning against rocks of granite. As nothing in my mind is more interesting for theory, than the junction of mountains of different orders, I determined to examine this; but as it was too late in the day, I went to sleep at Courmayeur, distant from it two leagues, and returned on the morrow.

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* § 872.

" Quitting the bottom of the valley, you must ascend for nearly three quarters of an hour, to arrive where the schisti touch the granite. These schisti, which at a distance only appeared a thin surface, adhering against the foot of the mountain, are a considerable mass of different layers. The substance which composes the greater part of these layers is remarkable, in that it briskly effervesces with acids, and yet very easily melts with the blow-pipe into a clear green transparent glass; which runs and sinks on the tube of glass to which it has been fixed.

" Its colour is blackish, and its grain resembles that of a limestone; I wished to see what was the quantity of free absorbent earth that this rock contained: I pulverised 100 grains of it, which I pounded for an hour in distilled vinegar; this acid dissolved the half of it, and those 50 grains were found composed of 44 grains of lime and 6 of magnesia. The other 50 grains which had refused to dissolve in the vinegar, were placed in decoction in aqua regis; being dissolved assisted by heat, 17,47 grains of lime, 2,25 of argil, and 1,42 of iron, were extracted from it, there remained 27 grains and a half of indissoluble siliceous earth. Uniting the products of these two operations, 100 grains of this schistus were found to contain, Lime 61,45, Silex 27,50, Magnesia 6,00, Argil 2,25, Iron 1,42, Water, air, and loss 1,38. Total 100,00.

"The layers of this schistus are intermingled with layers of a fine sandstone; but little coherent, and which resolves of itself in a white sand, found in quantity at the foot of these same layers. The weak gluten, which unites these grains of sand, is of a calcareous nature.

"These layers are a little bent; but their general position, of those at least which are the lowest, is vertical, excepting by a few degrees, in which they recline against the mountain. There can be no doubt on the position of the beds of these schisti, because they are exactly parallel to the plates of which they are composed. But these layers are cut here and there, and at right angles, by clefts parallel to one another, and which all bend alike, descending to the S. W. under an angle of about 50 degrees. These clefts leave intervals between them; here a foot, there only a few inches. When they are observed at a distance, it is impossible not to take them for divisions of the beds of the rock, so important is it in these researches to see the object close, and observe it in detail; for the interior structure of the rock can alone decide between sections which cross at right angles, which are those which denote the position of the beds. I have already mentioned what I thought of the origin of the fissures which thus cut the beds, and I shall elsewhere refer to it again.

"I have distinguished four very distinct shades in the transition of these schisti to granites.

"The first layers of schistus, where some alteration is observed, assume plates more wavy, brighter, more resembling mica; but they have otherwise the same properties with the others.

"The next are still more waved, plates of real mica are observed, and besides a mixture of quartz, which yields fire with steel, although the rock still effervesces with acids. Veins of a black substance are observed in this same rock, bright, composed of little rhomboids, which appear to be the crystallisation of the purest substance of the schistus; for these crystals dissolve with effervescence in acids, without leaving any perceptible residue; and yet they very easily melt under the blow-pipe into a greenish and transparent glass, which sinks on the point of the glass tube.

"The third shade is a real quartz, mixed with a little mica, and which does not effervesce.

"The fourth is a grey granite, with very small grains of quartz, felspar, and mica.

"This transition in general occupies an inconsiderable thickness; in some places these four layers, taken together, are not more than a foot: nevertheless, the granite does not acquire all its perfection, its grains are not very exact and distinct, till a distance of some feet from its junction. Layers are observed in this perfect granite; they are parallel to all those which form this transition.

"Following it round the mountain, I traced this junction of schisti to a considerable distance, by sounding every where with a hammer the bordering beds: I observed no particular difference in the nature of the layers, which form the transition between granite and schistus; but I found some alteration in the position of the beds: advancing towards the S. W. I observed schisti as well as granites overhanging towards the valley, here of 35, there even of 47 degrees. The direction of the layers also changes a little. Those nearest to Col Ferret run to the S. S. W., while those most distant from this same Col, run about 30 degrees more to the west.

"I observed also, in some places, vitriolic effervescences which distilled, sometimes from the schistus, sometimes from the granite itself."

In his interesting account of the extinct volcano of Beaulieu, in the south of France, he thus describes a singular stone, which was supposed to be transilient, or passing from limestone to flint. It probably rather belongs to the Diamictonic; but the remarks of Saussure rather place it in this division.

"The upper beds of that rock appear to me calcareous, compact; but the lower, or those which approach nearest to the supposed orifice of the crater, are of a substance that has been confounded with petrosilex, but whose essential characters differ from it. I call it *silici-calx*, because it is composed of silex mixed with calcareous earth.

"It is of a white colour, which, in some specimens, inclines to a grey, in others to a red. Its fracture is perfectly conchoidal and smooth, but without lustre, and of a fine paste. It cannot be called scaly, although in some places there are large scales. Its fragments are sharp, and translucent on the edges. It is a little more than semi-hard, only being capable of being scratched with the point of a knife, and yielding, though rarely, some sparks with steel.

"It makes a weak and long effervescence with acids; it then loses a great part of its hardness, but however not so much as to become friable or spotty; and its edges then become more translucent.

"Reduced to powder, and digested in the nitrous acid, it loses 45 hundredths of its weight; and the residuum, of a fine white, and truly siliceous, dissolves with effervescence in the mineral alkali. It is cold to the touch: its specific weight is 2,301.

"Under the blow-pipe it begins to crack a little, then it melts in boiling to a white scoria; the fusibility of which expressed by a globule, equal to 0,8, answers to 71 degrees of Wedgewood's thermometer; but the small fragments that have been digested in the nitrous acid, are much more refractory, on account of their being deprived of the calcareous earth, the principle of their fusibility. Globules of them can only be formed equal to 0,04, corresponding with the 1426 degree of Wedgewood.

"There are some small knots of flint scattered in the interior of this stone; and its surface is frequently covered with pretty black dendrites.

"I have already observed, that naturalists have confounded the stones of this kind with petrosilex, and particularly with the *petrosilex æquabilis* of Wallerius. But its properties are remarkable, and too different from those of the secondary petrosilex or hornstein of Werner, not to form a separate kind*.

"Besides, the effervescence arising from calcareous earth, scattered amongst the elements, as in the *silicicalce*, must be well distinguished from that which arises from calcareous parts, accidentally enclosed between the leaves; or in the veins of secondary petrosilex, which have a veined or schistose form.

"Very near this, in the fields, are found fragments of common compact limestone, *dichter kalkstein* of Werner, full of sea-shells, and above all of *vis*, screws, or tubercular strombites. There are also frequently found in the same stones veins of common flint."†

In another passage, § 1537, our excellent author describes the same substance, and the rocks which accompanied it. As his work will probably never be translated, no apology needs be offered for inserting the passage, though somewhat long. On his route from Aix to Avignon, he perceived along the high road horizontal beds of a whitish limestone, which alternate with beds of an earth of the same colour. These beds of stone enclose, in the middle of their thickness, another stone in which are contained kernels of flint.

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* "I think we must refer to this genus the stone known at Rome by the name of *Selce de Madrid*. Patrini Gabinetto Mineralogico, t. i. p. 161."

† § 1524.

"Each of these beds, whose thickness varies from one inch to five or six, is therefore composed of three different substances: 1. White stone; 2. Brown stone; 3. Flint.

"White stone, No. 1, forms the upper and lower part of each bed; it is calcareous, of a white approaching to red; it breaks in irregular uneven fragments, with obtuse angles; its fracture presents a mixture of grains, more or less small, shapeless, earthy, and without any lustre. It is rough to the touch, and stains the hands a little; it is soft, but however less so than chalk. It therefore differs from this by being a little more hard, and by a coarser grain. It dissolves in acids with considerable effervescence, and leaves behind a small argillaceous sediment.

"The brown stone, No. 2, which occupies the middle of the beds of that kind of chalk, is of a clear Isabella-brown; it breaks in conchoidal fragments with sharp edges, and whose angles and small scales are translucent; its fracture is compact with scales, being sometimes very small, sometimes pretty large. Its lustre is weak, a little shining; its streak is of a whitish grey; its hardness rather more than that of marble, although it yields no sparks with steel. In the places where it borders on the chalky stone, it melts into it by gradual shades. Under the *blow*-pipe it is changed, though difficultly, into a beautiful white scoria, besprinkled with small bubbles; the fusibility of which, expressed by a globule equal to 0,3, answers to the 189 degree of Wedgewood.

"It effervesces in the nitrous acid with many little bubbles; and a small piece, of the thickness of a *line*, after remaining in it twenty-four hours, is found to have lost much of its hardness, especially at the surface; it even stains a little brownish, and breaks between the fingers, without however being reduced to powder. Its fusibility is then only 0,13, or 581 degrees of Wedgewood.

"According to these characters, it is a kind of the stone which I have described in 1524, by the name of *silicicalce*.

"The nodules (3) enclosed in that brown stone, are of a fawn-colour, translucent, hard, their fracture perfectly conchoidal, smooth in some parts, a little scaly in others, having, in short, all the characters of true flint, or of the *feuerstein* of Werner.

"These nodules of flint are scattered in the brown stone; yet they more frequently occupy the upper and lower part of the bed of this stone, and are found thus contiguous, on the one side to the white chalky stone, and on the other to the silicicalce. There are also scattered here and there, in the body of the chalky stone, some small flints, and some small silicicalces, which are not fragments, but pieces formed in the spots they occupy.

"These observations and experiments appear to me to prove that these intermediate kinds we have sometimes represented as passages from one kind to another, or as limestones half metamorphosed into flint, are often only mechanical mixtures of one kind with another. We here see that the calcareous earth has preserved in this petrosilex all its solubility in acids; and when we extract it from the mixture, what remains separated from the dissolvent, is still refractory like pure silex.

"I shall also draw an example from this stone of the insufficiency of the external characters of a rock to determine its nature, and even only to decide whether it be simple or compound. Indeed in the *silicicalce*, the calcareous parts are not combined with the siliceous, since the nitrous acid extracts them with effervescence without destroying the aggregation of the stone. They are then only interposed between the siliceous elements; however, the whole that results from it, observed even with a strong magnifying glass, appears to be absolutely homogenous; and ought consequently, according to the rule of the lithological nomenclature, to be considered as a simple stone.

" If then we owe gratitude to Mr. Werner, for having given to the exterior characters all the perfection of which they were susceptible; we must omit no means which may afford us lights upon the nature and composition of bodies, with which our senses alone are incapable of furnishing us.

" We frequently find on the same road, between Aix and Lambesc, the same flints enclosed in chalky calcareous stone."*

Rocks of Mont Jovet.

His account may also be subjoined of a singular assemblage of heterogenous rocks, which could not well be separated, as the sudden transitions form their chief curiosity. These he discovered on Mont Jovet, between St. Vincent and Verrex, not far from the city of Aosta; being constant alternations of arrects or uprights of steatite, basaltin, siderite, garnet rock, and calcareous granitoid.

Serpentine, with brilliant plates of green transparent talc, sometimes undulated, at others fibrous or laminar.

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* Sauss. 1524.

A large rock of siderite, partly very hard, and yielding sparks with steel; partly laminar, and more tender. The hard part marbled with brown, from the decomposition of the iron. It is crystallised.

A massive garnet rock, either in mass or confusedly crystallised with deep green siderite, in brilliant needles, being a mixture of the greatest beauty*. The infusibility of the garnet, Saussure ascribes to the refractory matrix; a remark that may be applied in many other instances, and chemists should often analyse the gangart.

Another rock of siderite, brown where composed of flat plates, green when of little needles, confusedly interlaced. His greenish schistus, of a fine *pierre de corne*, seems a chlorite slate.

The calcareous granitoid of limestone, quartz, and mica, alternates repeatedly at Mont Jovet with the other rocks; and Saussure observed another kind, consisting of rhomboidal calcareous spar of a fawn-colour, of a pure white quartz, and white talc, in soft brilliant plates; a most beautiful and uncommon rock†.

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* Some fragments are of pure red.

† Sauss. 965.

Among the transilient rocks may also be classed many which are imperfect in their structure, and so irregular in different portions, that they embarrass the scientific inquirer. In fact, rocks of this nature constitute a large portion of the globe; while the specimens in cabinets chiefly consist of what are called well characterised. To detail and class these imperfect rocks would be infinite, and uninteresting, so a few observations may suffice.

Imperfect and irregular rocks of Britain.

Great Britain and Ireland, in particular, often afford irregular and imperfect rocks. Even the granite of Scotland rarely presents the regular crystallisation observable in that of some other countries; consisting chiefly of felspar, with a little quartz, and remote spangles of mica. Dr. Townson, in his mineralogy of Shropshire, has specified many irregular rocks of this kind; such as an imperfect or ill characterised granite, composed of red felspar, white quartz, and blackish green hornblende. But this appearance only occurs in the most perfect specimens; while in general it may rather be called a sandstone, seemingly formed by deposition. Such is also the rock of Raglith, formed of grains of felspar and quartz, in an earthy base*.

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* Townson's Tracts, p. 163, 168, 188, &c.

Malvern hills.

The mineralogy of the Malvern hills, in Worcestershire, also presents several imperfect rocks, of the nature of granite, and chert, and wacken, with mica slate and schistose siderite. But this intelligent writer's own description will convey the clearest idea. He introduces it by the following observation, which indicates their proper place in this division: "All these rocks frequently *pass imperceptibly into each other;* whence arise various strange mixtures, and imperfectly characterised fossils."

"These rocks are singularly blended together. In some parts the granitoid rock, which contains scarce any mica, runs as it were in thick irregular veins, or forms patches amongst the wacken and chert; and these likewise are similarly situated amongst the granite, sometimes the one, sometimes the other, forming the principal mass.

"In walking over these hills, I collected the following specimens; none of which I found any where to constitute a considerable portion of them, except the granitoid kind; and this, though greatly varying in its nature, I found in considerable rocks on the summit of the ridge between Great Malvern and the Well House.

"1. Red granite, with scarce any silver mica, and a little hornblende.

"2. Fat quartz, in which a few particles of red felspar are imbedded.

"3. Quartz and felspar united in equal portions, rather in short stripes than in grains, with a few minute spangles of mica. The different components being in very small quantities, constitute a body which, at first sight, appears homogenous.

"4. Quartz and felspar, in such minute grains as to resemble a sand-stone.

"5. Red compact felspar? In this I cannot, even with a good lens, distinguish any admixture of quartz; but when held in a particular direction, the silver mica is visible. I conjecture this to be of the same nature as the preceding, but to be composed of much minuter parts.

"6. Red granite, or rather felspar and quartz, forming a vein or stripe in spatous (granular) hornblende; which is likewise interspersed with red particles of felspar.

"7. Two stripes of the preceding granitoid mixture, separated by brownish mica.

"8. Stripes of the preceding granitoid mixture imbedded in, and separated by, a greenish mass, probably of the nature of hornblende.

"9. Red felspar, in irregular spots or blotches of the size of a large pea, and in smaller particles, in greenish spatous hornblende.

"10. Black spatous hornblende, interspersed with small particles of red felspar.

"11. Fine grained black spatous hornblende, interspersed with very few and very minute particles of reddish felspar.

"12. A brown stone, and, to the naked eye, almost homogenous; but which is a mixture of nearly equal portions of red felspar and black hornblende; but both in very minute particles.

"13. Black-grey wacken.

"14. The same, with a spot of siskin green lapis nephriticus, or kind of jad.

"15. A mixture of hornblende and the same lapis nephriticus, with some quartz, all so intimately mixed as to form nearly a homogenous basis or ground, in which are small streaks and particles of red felspar.

"16. Reddish grey petrosilex, including a few particles of pellucid felspar.

"All these specimens are from about three or four miles of the centre of the chain; the other parts of it I never examined."*

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* Townson's Tracts, p. 216.

DOMAIN XI.

DECOMPOSED.

◆

THE decomposition of rocks forms a striking feature in geology, as a great part of the productive soil, and many of the substances used in important manufactories, may be considered as chiefly derived from this circumstance. Several of the most useful clays are reputed by some to be merely decompositions of felspar; the

Importance of the subject.

mixture of sand being a decomposition of quartz. **Loam.** Bergman found the loam near London, to contain only 13 of argil; the remaining 87 being a redish grey sand, as fine as flour. **Mould.** What is called mould, consists chiefly of vegetable and animal remains. The fall of leaves in a forest creates a fine black mould.

In various parts of England, and other countries, the loam is of a red colour, and proceeds in what may be called belts or zones (for strata can only be superimposed on each other) for a great distance, but with various interruptions. This red tinge can scarcely arise from the decomposed felspar of red primeval granite, as some have supposed; for in that case the hardest nodules of the granite would probably still be found, as in the red sand-stone; but may merely proceed from the admixture of red oxyd of iron, while in other spots the black oxyd may predominate. Argillaceous earth is found in the most primitive substances; and theory can scarcely be expected to determine whether the fertile clay, which forms so prodigious and important a portion of the surface of this globe, and furnishes aliment to animals and vegetables, arises from a decomposition effected, during myriads of ages, by the superincumbent waters; or by a mere deposition from the original mass and constitution of the waters themselves.

On the decomposition of rocks, the observations of a skilful chemist must be particularly exact and interesting, for which reason those of Mr. Kirwan are extracted; more especially as they abound with examples which are essential to the nature of the present work. It may also be prefaced, that the decomposed rocks have never hitherto been treated in any professed work of mineralogy, so that the novelty of the subject calls for every aid of illustration.

Kirwan's explanation.

"Decomposition consists in the separation of the constituent parts of a stone, or other substance; and may be either total or partial. Disintegration denotes the separation only of the integrant parts; both often take place in the same substance.

Causes.

"The only causes of mere disintegration as yet known, are the vicissitudes of the atmosphere; the absorption and congelation of water; the sudden dilatation or contraction produced by the former, particularly when extreme, cannot but loosen the texture of most stony substances, and when aided by the absorption of water, strongly tend to separate them. The water thus received in their minutest rifts, being afterwards frozen, bursts them with incredible force, of which frequent instances occur in the northern countries, and in the more elevated mountains of the southern, where the most sudden transitions of heat and cold, and the highest degrees of the latter, frequently prevail; and hence the broken craggy state of their loftiest summits*.

"The known external causes of decomposition, are water, oxygen, and fixed air.

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* Crantz has informed us that, in Greenland, the rocks are often heard to burst with a noise like thunder.—P.

"The internal causes are, the bases most capable of forming a union with the external: as saline substances, sulphur, slightly oxygenated calces of iron, or of manganese, lime, argil, bitumen, carbon, and mephitic air; which is certainly contained in many stony substances, as Dr. Priestly has shown *in the first volume of his last edition*, p. 64; but as to its nature and effects, they are at present too little known; all these are assisted by a loose texture of the substance acted upon.

Salts.

"Saline substances, particularly when (relatively to their mass) they present a large surface, are dissolved by water, and consequently the stones, of which they sometimes form a component part, are decomposed; thus muriacite, which consists of 27 per cent gypsum, 14 common salt, 5 mild calx, and 53 micaceous sand, must be decomposed when long subject to the action of water.

Sulphur.

"Sulphur promotes decomposition by

absorbing oxygen, while it is thus converted into vitriolic acid; but moisture is also requisite. To this cause the decomposition of such stones as contain pyrites is to be attributed; it seldom acts, however, unless united to some metallic substance; and hence its combinations with argil, unless assisted by heat, are not sensibly decomposed, or only in a great length of time.

Oxyd of iron.

"Calces of iron, moderately oxygenated, are the most general cause of decomposition, particularly when assisted by a loose texture, and the other causes of disintegration; these act by absorbing a greater proportion of oxygen and fixed air, but require also the assistance of moisture. By this absorption they gradually swell, and are disunited from the other constituent parts of the stone, into whose composition they enter. When least oxygenated, their colour is black, or brown, or bluish; and in some instances, when united with argil and magnesia, grey or greenish grey; the former in proportion as they become more oxygenated, become purple, red, orange, and finally pale yellow; the latter becomes at first blue, then purple, red, &c.

" Iron in its perfect metallic state, or at least but slightly oxygenated, also decomposes water; but if exposed to the air, it becomes farther oxygenated; and the compound into which it enters gradually withers, as Dr. Higgins observed, in imitating pouzzolana (on Cements, 124).

" But stones, into whose composition calces of iron highly oxygenated seem to have originally entered, are very difficultly decomposed, as red jaspers, &c. as they already possess nearly as much as they can absorb.

" Manganese, when slightly oxygenated, is known to attract oxygen strongly, particularly with the assistance of heat and moisture; hence it is, in many cases, a principle of decomposition, as in siderocalcites, &c.; it also frequently assists or promotes that effected by calces of iron.

" Lime, from its attraction to fixed air, and its solubility in water, must promote, in favourable circumstances, the decomposition of stones, of which it forms a constituent part; to it the decomposition of felspars, and many zeolites, may in part be attributed.

" Argil, when its induration does not exceed 7, must, by the common annual vicissitudes of heat and cold, gradually become rifty, absorb, soften and swell, and thus promote disintegration and decomposition.

" Bitumen is said to form the cement of some limestones, and probably of various other species. Bowles found it so in various parts of Spain, and Flurl in Bavaria; and to its fusion and withering (probably by attracting oxygen), he attributes the disintegration of several compact limestones in Bavaria (p. 78).

" Carbon has lately been found in several species of stone; as it powerfully attracts oxygen, to it we may perhaps attribute the disintegration of many of them, as marls, marlites, some argillites, shales, &c.

" Mephitic air (the azote of the French) by its property of forming nitrous acid, when, during its nascent state, it is gradually brought into contact with the oxygen of the atmosphere, in a moderately dry state, may also promote decomposition; calcareous stones are known to contain it in pretty considerable proportion, and those that contain animal remains, probably most; from this consideration we may derive some explanation of a very remarkable phenomenon, related by M. Dolomieu 36 Roz. 116. 'All the houses of Malta are built of a fine grained limestone, of a loose and soft texture, but which hardens by exposure to the air. There is a circumstance which hastens its destruction and reduces it to powder, namely, when it is wetted by sea water; after this it never dries, but is covered by a saline effervescence; and a crust is found some tenths of an inch thick, mixed with common salt, nitre, and nitrated lime; under this crust the stone moulders into dust, the crust falls off, and other crusts are successively formed, until the whole stone is

Limestone of Malta.

destroyed. A single drop of sea water is sufficient to produce the germ of destruction; it forms a spot which gradually increases, and spreads like a caries through the whole mass of the stone: nor does it stop there, but after some time affects all the neighbouring stones in the wall. The stones most subject to this malady are those that contain most magnesia; those which are fine grained and of a close texture, resist most.' Short as this account is, it appears from it that the limestone of Malta contains both calcareous earth and magnesia, but most probably in a mild state; and the stone being of the looser kind, is of the species which is known to contain most mephitic air. M. Dolomieu shows, at the end of his tract on the Lipari Islands, that the atmosphere of Malta in some seasons, when a south wind blows, is remarkably fouled with mephitic air; and at other times, when a north wind blows, remarkably pure; and hence, of all others, most fit for the generation of nitrous acid.—Again, sea water, besides common salt, contains a notable proportion of muriated magnesia, and a small proportion of selenite. From these data we may infer, that when this stone is wetted by sea water, the selenite is decomposed by the mild magnesia contained in the stone, and intimately mixed with the calcareous earth. Of this decomposition, two results deserve attention: 1. the production of vitriolic Epsom. 2. the extrication of mephitic air; the muriatic magnesia of the sea water serving, during this extrication, the purpose of attracting and detaining a sufficiency of moisture. This air thus slowly generated, and meeting the dry oxygen of the atmosphere, forms nitrous acid, highly mephitised; but it soon acquires a due proportion of oxygen, by deoxygenating the vitriolic contained in the Epsom salt, which, by successive depredations of this sort, is gradually destroyed. Part also must unite to the mild calx, which in its turn is decomposed by the remaining mild magnesia; more mephitic air is set loose, and more nitrous acid is produced, until the stone is destroyed. How the alkaline part of the nitre, which is one of the products resulting from the decomposition of this stone, is formed, is as yet mysterious; is it not from the tartarin lately discovered in clays and many stones? I am as yet inclined to think, that it is derived from the putrefaction of vegetable and animal substances; and though nitrous acid formed of oxygen and air, from putrefying substances, be found united not only to the absorbent earths to which it is exposed, but also to a fixed alkali; yet I should rather suppose that the alkali is conveyed into those earths by the putrid air, than newly formed; and the reason is, that tartarin, notwithstanding its fixity, is also found in soot; and in the same manner may be elevated in putrid exhalations. As to the common salt, said also by Dolomieu to be found in the blisters of this mouldering stone, I am as yet in doubt; for common salt was also said to accompany the native nitre found in the *pulo* of Apulia; yet Klaproth, in analysing this nitrated earth, could find none:

see Zimmerman's account of this native nitre. (36 Roy. 111, 113, and 1 Klap. 319.)

"So also when the calx of iron contained in stones is but slightly oxygenated, it may, by reason of the close texture of the stone, remain undecomposed for ages; but if by any accident, as fracture, or contact with some saline matter, or the alternate reception and dismissal of water, the reception of more oxygen is facilitated, a decomposition will commence, which, as in the former case, will spread like a caries, because the less oxygenated part of the iron takes oxygen more easily from the more oxygenated part, than from the atmosphere; by reason, that the absorbed oxygen is more condensed than it is in the atmosphere. Thus iron inserted into a highly oxygenated solution of vitriol of iron, and which therefore refuses to crystallise, will take up the excess of oxygen, and thus restore the solution to a crystallisable state; or as calx of tin takes up oxygen from calces of silver, antimony, &c.

in the beautiful experiments of Pelletier, (12 An. Chym. 229, &c.)

Ferruginous rocks.

"Hence also, ferruginous stones near or upon the surface of the earth, being more exposed to air and moisture, and the disruptive action of growing vegetables, whose roots pierce through their minutest rifts, and by swelling burst them, are more exposed and subject to decomposition. Water carries down the ferruginous particles into the lower strata, and forms there those illinitions and masses of pisiform argillaceous iron ore, which Buffon and others have, without sufficient reason, derived from decayed vegetables.

"Basalt, when pure, strongly resists decomposition, or its surface alone bears any marks of it; the argillaceous, siliceous, and calcareous ingredients, and part of the ferruginous, soon recombining and forming a hard crust, which invests and protects the remainder of the stone. But wacken is very easily decomposed; and hence the basalts or traps, into whose composition

Wacken.

it enters, yield easily to the decomposing principle. Some granites, I may say most, are in appropriate circumstances not difficultly decomposed, the mica and felspar are chiefly affected: the same may be also said of most sand-stones, particularly those whose cement is argillaceous or ferruginous, and many porphyries and gneisses."*

Importance to the arts.

From these interesting observations it will appear, that the decomposition of rocks is not only a curious subject in itself, but of the greatest importance to the arts, particularly architecture and sculpture. Many noble edifices have soon become disfigured, because the architect did not know the easy decomposition of the materials. Thus at Trianon the pillars are already decayed, because the argillaceous nature of the marble of Campan will not bear exposure in the open air, where it soon exfoliates. At Oxford it has been observed that some of the public buildings are injured, because the builders had not studied the nature of the stone, which requires to be laid in its original position in the quarry, that the first compression may still exist, as otherwise it will imbibe the moisture, and thus split or crumble in frosty weather. Sculptors are singularly anxious that the stone which they use should not be subject to this defect; and their example should be followed by architects, as the duration of their works and reputation depends entirely on this branch of knowledge. It would appear that the ancients, who always mingled the useful with the ornamental, had particularly investigated this subject, even in very early times; for the Egyptians, in their eternal monuments, had already learned to prefer granite and porphyry, the two most durable substances in nature; and which have the additional advantage that they afford no temptation for destruction, because they cannot, like marble, be converted into lime: for some of the noblest monuments of Greece have been used for this purpose by the barbarous Turks; and a temple or statue of Diana has been turned into cement, for the voluptuous apartments of a Haram. It is also conceived by antiquaries, that some of the finest monuments of ancient Rome perished in this manner during the middle ages.

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* Kirwan's Geological Essays, p. 143—153.

Hard stones may decompose.

It must not be forgotten that stones apparently hard, are sometimes more subject to decay than those of a softer contexture. The pyramids of Egypt have suffered little degradation, though constructed with a soft calcareous konite*. The Roman Pharos, at Dover, remains almost entire, though built with a soft stalactitic tufa, found in abundance on the shores of several rivers; for example, the Tees, in the north of England. The transportation of this stone from a distance, seems to evince that there was some reason for giving it a preference; and as it is coralloid in its structure, it was perhaps justly conceived that it would emit the moisture with the same ease as it was received, and hence be little subject to decomposition. The conjecture, if such, was certainly verified by the event. From this, and numerous other examples, it may be inferred that the ancient architects observed, with a most scrutinizing eye, the nature and the structure of the stone which they employed; an important circumstance which has not met with due consideration among the moderns.

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* Strabo says, that one of the pyramids was more expensive, as the lower part was built with basalt, from Ethiopia; a circumstance which seems to have escaped the attention of travellers, probably from the white crust which invests basalt. But some were covered with granite: see Dom. II.

The same considerations are also of the greatest importance in private buildings, where stone is abundant and in general request; and the product of any new quarry should be put to several tests, and severely examined, before it be brought into use. The example of the houses of Malta, above mentioned by Mr. Kirwan, is a striking lesson of this kind; and some modern buildings in Scotland are more decayed than the ancient. If iron, clay, or even perhaps some magnesian mixtures, be much intermingled, the stone is apt to become carious. But the magnesian rocks in general are little subject to decay; and serpentine, resisting moisture by its unctuous nature, forms some of the boldest summits and promontories. It was perhaps this consideration which induced the preference of ollite, or potstone, in the construction of the Duke of Argyle's noble mansion at Inverary.

These observations can scarcely demand excuse, as being digressive, for the utility of any subject is its most laudable quality: *nisi utile est quod facimus, stulta est gloria.* But to return to considerations more immediately connected with the nature of this work, it must not be forgotten that the able illustrator of the Huttonian theory, has treated the subject of decomposed rocks, which may be said indeed to form the very foundation of that system, with his usual talents; but not with that long and laborious discussion which was to have been expected on a topic so important to his purpose. After describing the plain of Crau, at the mouth of the Rhone, a space of about 20 square leagues covered with quartzose pebbles, and which Saussure observed to proceed from the decomposition of a vast stratum of pudding-stone, which underlies the whole; the intelligent author thus proceeds.

Playfair's observations.

"The argument for the decomposition of stony substances, which is afforded by the state of this singular plain, may be confirmed by the appearances observed in many extensive tracts of land all over the world, and especially in some parts of Great Britain. The road to Exeter from Taunton Dean, between the latter and Honiton, passes over a large heath or down, considerably elevated above the plain of Taunton. The rock which is the base of this heath, as far as can be discovered, is limestone; and over the surface of it large flints, in the form of gravel, are very thickly spread. There is no higher ground in the neighbourhood from which this gravel can be supposed to have come, nor any stream that can have carried it; so that no explanation of it remains, but that it is formed of the flints contained in beds of limestone which are now worn away. The flints on the heath are precisely of the kind found in limestone; many of them are not much worn, and cannot have travelled far from the rock in which they were originally contained. It seems certain, therefore, that they are the *debris* of limestone strata, now entirely decomposed, that once lay above the strata, which at present form the base of this elevated plain, and probably covered them to a considerable height. This explanation carries the greater probability with it, that any other way of accounting for the fact in question, as the travelling of the gravel from higher grounds, or the immersion of the surface under the sea, will imply changes in the face of the country, incomparably greater than are here supposed. Our hypothesis seems to give the *minimum* of all the kinds of change that can possibly account for the phenomenon.

"The same remarks may be made on the high plain of Blackdown, which the road passes over in going from Exeter to the westward. The flints there are disseminated over the surface as thickly as in the other instance, and can be explained only on the same supposition.

"Again, in the interior of England, beginning from about Worcester and Birmingham, and proceeding north-east through Warwickshire, Leicestershire, Nottinghamshire, as far as the south of Yorkshire, a particular species of highly indurated gravel, formed of granulated quartz, is found every where in great abundance. This same gravel extends to the west and north-west as far as Ashburn, in Derbyshire; and perhaps still farther to the north. The quantity of it about Birmingham is very remarkable, as well as in many other places; and the phenomenon is the more surprising, that no rock of the same sort is seen in its native place. It is such gravel as might be expected in a mountainous country; in Scotland, for instance, or in Swisserland; but not at all in the fertile and secondary plains of England.

"This enigma is explained, however,

when it is observed, that the basis of the whole tract just described is a red sandstone, often containing in it a hard quartzy gravel, perfectly similar to that which has just been mentioned. From the dissolution of beds of this sandstone, which formerly covered the present, there can be no doubt that this gravel is derived. But as the gravel is in general thinly dispersed through the sandstone, and abounds only in some of its layers, it should therefore seem that a vast body of strata must have been worn away and decomposed, before such quantities of gravel as now exist in the soil could have been let loose.

"I have said that a rock, capable of affording such gravel as this, is not to be found in the tract of country just mentioned. This, however, is not strictly true; for in Worcestershire, between Bromesgrove and Birmingham, about seven miles from the latter, a rock is found consisting of indurated strata, greatly elevated, and without doubt primitive, from the detritus of which such gravel as we are now speaking of might be produced. These strata seem to rise up from under the secondary, where they are intersected by the road; and, for as much as appears, are not of great thickness, so that they cannot have afforded the materials of this gravel directly, though they may have done so indirectly, or through the medium of the red sandstone; that is to say, a primary rock of which they are the remains, may have afforded materials for the gravel in the sandstone; and this sandstone may, in its turn, have afforded the materials of the present soil, and particularly the gravel contained in it.

"Pudding-stones being very liable to decomposition, have probably, in most countries, afforded a large proportion of the loose gravel now found in the soil. The mountains, or at least hills, of this rock, which are found in many places, prove the great extent of such decomposition. Mount Rigi, for instance, on the side of the lake of Lucerne, is entirely of pudding-stone, and is 742 toises in height, measured from the level of the lake. By the descriptions given of it, as well as of other hills of the same kind in Swisserland, we may, without due attention, be led to suppose that they are entirely formed of loose gravel. Even M. Saussure's description is chargeable with this fault; though, when attended to, it will be found to contain a sufficient proof that this hill is composed of real pudding-stone. The nature of the thing also, would be sufficient to convince us that a hill, more than 4000 feet in height, could not consist of loose and unconsolidated materials.

"If then we regard Mount Rigi as the remains of a body of pudding-stone strata, we must conclude that these strata were originally more extensive; and the adjacent valleys and plains will serve, in some degree, to measure the quantity of them which time has destroyed."*

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* Playfair, 373.

The novelty of the topic, in a professed work of this nature, will be a sufficient apology for the length of these introductory observations: but it is now proper to pursue the plan proposed, by an arrangement of the chief decomposed rocks.

NOME I. DECOMPOSED BASALTIN.

The German mineralogists have not been deficient in their observation of this curious appearance. Karsten, in his catalogue of Leske's collection, has the following instances, among others, in the geographical series.

HYPONOME I.

Basaltin.

" 1525. Very fine splintery basalt, with half decayed chrysolite disseminated, and exteriorly decomposed to yellowish brown clay, from Rietstein, Saxony. Of Germany.

" 1533. Basalt, in which the chrysolite is become very steatitical through decay, from the same place.

" 1534. A piece of basalt with decayed chrysolite, wherein it is quite evident that the pores originate from the decay of the latter, from the same place.

" 1577. A piece of basalt, mixed partly with small grained chrysolite, partly with felspar, which, as is very frequently the case in granite, is decomposed to lithomarga; from Wachberg, beside Hartmansdorf.

"1667. Perfectly decayed basalt, which in some places contains a large quantity of earth resembling bole, with interposed basalt consisting of lamellar distinct concretions.

"1671. A pentahedral columnar tolerably large piece, which consists entirely of this earth, so that evidently the basalt must have been decomposed into it.

"Rem. It deserves to be noticed as a singular phenomenon, that a perfect hexahedral prism of chrysolite occurs in it.

"1819. A very decayed porous basalt fragment, which lay between the solid layers, and is called lava flag.

"1673. Very decayed porous basalt, which had better be called a basaltic amygdaloid, wherein are still contained abundant vestiges of the earth, with which these pores were formerly filled.

"1674. The same fossil, but the pores, not so uniform, are smaller and larger promiscuously.

"1675. The same fossil, penetrated more uniformly with the sulphur-yellow argillaceous mass, which gives to the whole, in the opinion of many geologists, a volcanic appearance."

HYPONOME II.

Amygdalite.

"305. Amygdaloid resembling basalt, in which small groups of zeolite occur, which in some places have totally lost their water of crystallisation.

"306. Similar amygdaloid, out of which all the extraneous parts have decayed, therefore the whole has a perfectly porous appearance; from Ascherofen, in the Thuringian forest.

"307. A piece of amygdaloid in which not only all the extraneous parts have decayed out, but the basis itself is also very much decayed; hence such varieties are not unfrequently called pumice; from Upper Lusatia."

As the opinion concerning the volcanic nature of basaltin seems rather to gain ground, it is not improbable that some of those substances are truly volcanic. When we consider the vast number of volcanoes in Asia and America, amounting to about one hundred and fifty, we may very reasonably infer that many in Europe may have become extinct. As these appearances only affect small spots, prejudice on either side becomes truly ludicrous; and its excess will, with rational minds, turn the scale upon the other side. What shall be said, when a late writer has informed us, that pumice itself is commonly a Neptunian substance?

NOME II. D. PORPHYRY.

In the same work, Karsten has given the following examples:

"208. A piece of porphyry in which the felspar is indeed entirely, but the basis *only slightly*, decomposed; from Norway.

"209. Porphyry in which the felspar is partly actually decomposed, but partly appears barely without lustre, the basis is become perfectly friable; from the vicinity of Regensburg.

"Rem. It is very frequently passed for tarras."

The remarkable stone which composes the Puy de Dome, where Pascal made his celebrated observations on the barometer, is a porphyry, which seems to be decomposed by volcanic heat. According to the experiments of Saussure, the base is an earthy felspar, or felsite.

Saxum metalliferum.

But the most celebrated decomposed porphyry is the *saxum metalliferum* of Baron de Born, which serves as a gangart to many rich mines of gold and silver in Hungary; and even to the noble opal, only found in that country. It is surprising that so many mistakes should have been made even by skilful mineralogists, while he repeatedly informs us himself that it is a grey argillaceous stone, mistaken by the miners for a sandstone, often containing crystals of felspar and quartz, and sometimes schorl. But in general the felspar itself seems to be decomposed, forming oblong white spots on the grey base, The gold and the opal would appear to have been formed after the decomposition of the rock. Opal and chalcedony are also found in entire porphyry; as well as veins of gold. The various porphyries of the German writers, occasion a strange confusion in the very nature of the substances.

Bornite.

The *saxum metalliferum* might as well be called Bornite, in honour of that great mineralogist.

HYPONOME I.

Bornite, from various parts of Hungary.

Micronome 1. The same, with native gold in thin plates and disseminated, from the same.

Micronome 2. The same, with sylvanite, from Nagyag in Transilvania.

Micronome 3. The same, with fine dendritic gold, from Cremnitz in Hungary.

HYPONOME II.

Micronome 1. The same, with noble opal, from Czerweniza in Hungary.

Micronome 2. The same, with black opal, from the same.

Micronome 3. The same, with milk opal, and many other kinds, from the same*.

NOME III. D. SLATE.

Some kinds of slate, especially those mixed with calcareous matter, easily exfoliate and decompose.

NOME IV. D. QUARTZ.

This substance is far from being easily decomposed; but, from some unexpected intermixture, it sometimes though rarely decomposes in granite, while the felspar remains entire. Mr. Kirwan has an article concerning earthy quartz, in which one would expect examples of decomposition; but the specimens rather seem to belong to the granular, and the cellular*. Ferruginous quartz seems the most liable to decomposition.

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* See Townson's Travels in Hungary, for an ample account of the opal mines.

NOME V. D. KERALITE.

Mr. Kirwan has observed, that when this substance begins to decompose it discovers the characters both of an earth and of a stone. Karsten has the following articles.

"S. 417. Hornstone, which in some parts is quite decomposed to clay, and from thence has acquired an earthy fracture.

"493. A decomposed hornstone, which is there called indurated fullers' earth. From Mainungen."

NOME VI. D. FELSPAR.

This substance which, owing to a mixture of pot-ash, is not of very difficult decomposition, passes into bole or lithomarga, kaolin or porcelain earth, and other sorts of clay. It is particularly affected in decomposed granite; to which article the reader is referred.

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* Min. i. 387.

HYPONOME I.

Felspar changed into kaolin.

HYPONOME II.

Into clay.

NOME VII. D. GRANITE.

The grandeur of this substance renders all its appearances interesting. The decomposition of granite may be considered on a large and on a small scale; in the former point of view, the subject has been well illustrated by Ramond, who has added a plate of its various appearances[*]. As the felspar is generally by far the most abundant substance, it might have been expected that granite would split into rhombs; but the forms cannot be called regular, though the sides, as Saussure has observed, are very plane or flat, intersecting, as if cut, all the component substances. According to Ramond,

Pyrenees.

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[*] Voyage au Mont Perdu, p. 20, &c. It is to be regretted that a style ludicrously emphatic and important, should disfigure a work, otherwise curious and interesting.

the final fragment, in the massive decomposition of granite, resembles a wedge*. One rock presents harder projecting veins, crossing in various directions; while the softer parts are excavated: perhaps a type in miniature of the granite veins observable on a larger scale, when the softer intervals may have been wasted, and their place, after many ages, supplied by schistus.

This massive decomposition of granite often takes place on the summits of mountains. It is said that Ben Nevis, the highest mountain in Great Britain, affords interesting examples of this kind; but, to the disgrace of our mineralogy, that mountain remains without due examination.

Sochondo.

The high ridge of Sochondo, in Chinese Tatary, which gives source to the great rivers of Onon and Argoon, is said to present summits consisting of large rocks, piled on each other in successive terraces. The mountains are probably granitic, like the celebrated *Odon-Tchelon*, in Daouria, near the same river Onon, which presents in its opulent bosom chrysolites, emeralds, and beryls; and which is thus described by an able observer.

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* De Luc, Geologie, 305, says that granite sometimes decomposes into circular portions, the rhombs having become spheroids. He saw piles of these in the Giant Mountains of Silesia, which, at a distance, resembled Dutch cheeses.

In some granites the decomposed mica becomes chlorite; but it seems too bold to assume that all chlorite is decomposed mica. See Journ. des Mines, iv. 42.

Odon-Tchelon. "Three or four leagues before arriving at the gang of the beryls, you begin to rise on the vast base of the mountain, entirely composed of the remains of its ancient summit. You may go on horseback to the foot of its actual summit, which is only elevated above its base about 1200 feet perpendicular; and it may be easily climbed on foot, as it is composed of granite tolerably friable, and which presents no precipices. This summit is formed like a horse-shoe, at the bottom of which is a spring, which waters the little valley formed by the two branches of the horse-shoe, whose aperture faces the S. E.; its extent in length being from 4 to 500 fathoms. It is upon the slope, which rises on the right in entering the valley, that there are two gangs of emeralds: the first is not far from the rivulet, and contains chrysolites; the second is near the middle of the height of the summit, rather advanced within the horse-shoe, and is that which contains the emeralds. The third gang is on the very crest of the summit, at the extremity of the horse-shoe, it contains the beryls."* If this celebrated mountain had not been decomposed, perhaps these precious mines would not have been discovered.

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* Patrin, ii. 24.

Kaolin.

On a smaller scale, the most usual decomposition of granite is where the felspar assumes the appearance of bole or lithomarga, of porcelain earth, or of fine clay. The noted Kaolin of the Chinese forming a chief ingredient of their famous porcelain manufactures, is a decomposed felspar, which seems mostly to proceed from an entire rock of that substance, as there seems to be no quartz; while that of Limoges, in France, the chief ingredient of the Sevres manufacture, may have been a granite in which the micarel is also decomposed; for there are numerous grains of quartz, which are carefully separated.

Granite, decomposed by volcanic heat, is common in Auvergne, where the lava has burst through superincumbent masses of that substance; but such appearances may rather be ranked among the volcanic; the decomposition here chiefly treated, being that effected by the influence of time and climate. Karsten has given the following examples of decomposed granite.

HYPONOME I.

"46. A piece of granite, in which the felspar has lost only a very minute portion of the water of crystallisation; from Upper Lusatia.

"47. Granite, with felspar somewhat farther decomposed; from Konigshain.

"48. Granite, with felspar considerably decomposed; from the same place.

"49. Granite, on one side of which the felspar is decomposed almost entirely to porcelain clay, but on the other not quite so much decomposed; from the county of Glaz.

HYPONOME II.

"50. Granite, in which the mica is decomposed into steatite, but the felspar very slightly; from Siberia.

"51. Granite with mica and felspar, quite decomposed; from the vicinity of Meissen.

"52. Granite, with almost perfectly decomposed mica, and felspar slightly so; from Kiphausen, in Thuringia.

"53. Granite with entirely decomposed mica, in which, on the other hand, the felspar still retains its perfect lustre; from the Altaischan Mountains.

"Rem. This is extremely rare, as the felspar is by far the most subject to decay."

NOME VIII. D. GNEISS.

In this substance, as in granite, the felspar and the mica are chiefly affected. Karsten gives the following examples:

HYPONOME I.

"*95.* Coarse fibrous gneiss, with slightly decomposed felspar, but further decomposed mica; from Swisserland.

"96. Gneiss with entirely decomposed felspar; from the Isaac, near Freyberg.

"97. Gneiss entirely decomposed, which is scarcely any longer distinguishable, except where the quartz still retains its appropriate structure; with an adhering compound of brown blende, martial pyrites, and some galena; from Freyberg."

The last is properly a vein-stone; and rocks are generally decomposed when in contact with metallic ores.

NOME IX. D. PITCH-STONE.

This substance being of a very compact and unctuous nature, its decomposition seems rather difficult. Among the volcanic specimens from Auvergne, in the author's cabinet, there is a piece of decomposed pitch-stone, which would be mistaken for brown iron ochre, if some parts did not retain their original character.

NOME X. D. SANDSTONE.

These glutenites, whatever be the cement, will decompose into sand. From the appearance of the rocks, in the vast sandy desarts in Africa and Asia, travellers have presumed that those prodigious extents of inert matter proceed from the decomposition of ranges of sandstone. This is perhaps the only decomposition which is destructive of all cultivation. It was natural for an Elector of Brandenburg, the lord of a sandy region, to inquire why God had created sand? While the vast and lofty chains of mountains, covered with perpetual snow, supply perpetual rivers, and perpetual fertility, to the most distant regions; those empires of sand present to human observation no symptom of utility, but, on the contrary, daily encroach on the fertile vales in their vicinity.

Sandstone rock and sand, from the desarts of Africa.

The same, from Arabia. The sand is red and coarse, and the decomposition would appear to proceed from iron; so that a metal of the greatest utility may, in the field of battle, or in the dreary desart, become the most pernicious to the human race.

Sandstone and sand, from the desart of Shamo.

NOME XI. D. CLAY-SLATE.

This is a common occurrence. Aluminous slate is particularly subject to decomposition.

NOME XII. D. SAUSSURITE.

This magnesian basaltin, one of the *pierres de corne* of Saussure, is not only liable to a superficial decomposition, forming a white crust; but, as it sometimes contains asbestos and amianthus, may become rifty, and thus split by the weather.

Decayed Saussurite, from the Alps.

The same, with amianthus, from the Pyrenees.

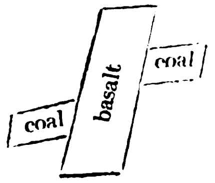
NOME XIII. D. MARBLE.

Argillaceous marble, as already mentioned, is peculiarly subject to decomposition. In the north of England, black marble has been observed, accompanied with a soft grey substance called rotten-stone; but this seems rather an adherence than a decomposition. Rotten-stone, though also used in polishing, must not be confounded with tripoli, which seems a mixture of very fine clay and sand, and is only found in veins.

NOME XV. D. COAL.

This substance, when in contact with what are called whin-dykes, those singular arrects or uprights which sometimes intersect whole mountains, is often observed to be decomposed; having lost its bitumen, and wearing the appearance of being charred. The Neptunists say, that the stone has absorbed the bitumen; while the Plutonists affirm that the melted stone, ejected from beneath, has caused the bitumen to evaporate.

Those immense arrects are often argillaceous, but more generally of a basaltic nature. They are sometimes of prodigious extent; one of them extending from Lothian through the estuary of the Forth into Fifeshire, a space of twelve or fifteen miles. It is observable, that where they intersect the coal, the beds subside in this position:



which seems to evince that they rose from beneath, having left an empty space in the direction of their ascent, into which the superincumbent bed subsided; for if a mere rupture had taken place, the descent of any substance from above would not have altered the original level of the beds. The eruptions of clay are frequent in American volcanoes, and may arise like sandstone, from the subterranean waters, which seem of far more extent and influence than is generally conceived. It ought also to be observed, if these arrects proceed in a northerly and southerly direction, or on any point of the compass from S. E. to N. W.; for such seems to be the common direction of chains of volcanoes, and of earthquakes; as perhaps in the desiccation of this globe, and the contraction at the poles, ruptures of different sizes took place in the shell, which were afterwards filled with subterranean waters, and combustible materials; while an exterior crust was gradually formed, with a distant resemblance of those on some morasses, considering the horrible chasms beneath. It is far from the intention of this work, a mere introduction to the science, to support any system; as it is of an eclectic nature, choosing the most authentic facts, and the most solid observations, from all the theories. If these ideas, however, should appear to savour of volcanism, let it be considered that we are on dangerous ground; for we now approach the volcanic domain.

The decomposition and ruin of mountains forming one of the grandest features in the history of the earth, a few examples may be subjoined; which shall be introduced by some observations of the greatest of petralogists, upon this singular and important topic.

Nature of decomposition.

"Another fact, of which I discovered the solution by examining these granites close and attentively, is that of those exfoliations which I had observed in the upper valley. It is a fact known by all mineralogists, that most rocks are softer in the interior of mountains than at their external part; and that in the air they acquire a considerable degree of hardness. It hence follows that the external part, or the edge of the vertical section of a large layer of granite, ought to harden by contact with the air, whilst the interior of the same layer retains a certain degree of softness. And so long as the lower layers remain a little soft, the enormous weight of all those that rest upon them, must in time compress them. But the external parts, hardened by contact with the air, are not susceptible of the same compression. They must then separate, and thus form the exfoliations which are observable.

"This explanation acquires the highest degree of probability, when we see some of these large plates still adhering, above and below, to the layers of which they were a part, and only separated in the middle, where they form a kind of convex arch on the external side; and the identity of the substance, as well as the parallel direction of their veins with those of rocks from which they are separated, demonstrate that they have formerly been united with them."*

Rapid.

The decomposition of these prodigious works of nature, the Alps, is far more rapid and incessant than might be supposed, increasing perhaps in proportion to their antiquity. The following grand and striking observation of Saussure, will not fail to impress the reader with this singular truth: "I do not exaggerate when I say that we did not pass an hour, without seeing or hearing large masses of rock precipitate themselves, with the sound of thunder, either from the sides of Mont Blanc, or the Aiguille Marbré, or from the crest on which we stood."†

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* Sauss. 1748.

† § 2048.

Ruin of Piura, or Pleurs.

Of the ruin of mountains, one of the most ancient examples recorded is that which occasioned the melancholy fate of the town of Piura, by the Swiss called Pleurs, in the county of Chiavenna; a handsome and commercial town, which was overwhelmed by the fall of Mount Conto, in 1618; when the inhabitants, in number 2430, were crushed or buried alive under the ruins*. The manufacture of ollite, which yielded to the town a revenue of 60,000 ducats, is said by some to have led to this disaster; the quarries having been so improvidently conducted as to undermine the mountain. But other writers regard it as proceeding from those natural causes, which have occasioned the fall of other mountains, in Swisserland and other countries.

Burnet introduces his account of this melancholy event by some observations on pot-stone, or ollite, which are indeed materially connected with the subject.

Ollite.

"There is a sort of pots of stone, that is used not only in all the kitchens here, but almost all Lombardy over, called *Lavege;* the stone feels oily and scaly, so that a scale sticks to one's finger that touches it, and is somewhat of the nature of a slate: there are but three mines of it known in these parts, one near Chavennes*, another in the Valteline, and the third in the Grisons; but the first is much the best. They generally cut it in the mine round, of about a foot and a half diameter, and about a foot and a quarter thick; and they work it in a mill, where the chisels that cut the stone are driven about by a wheel that is set a going by water, and which is so ordered, that he who manages the chisel, very easily draws forward the wheel out of the course of the water. They turn off first the outward coat of this stone, till it is exactly smooth, and then they separate one pot after another by those small and hooked chisels; by which they make a nest of pots, all one within another; the outward and biggest being as big as an ordinary beef-pot, and the inward pot being no bigger than a small pipkin: these they arm with hooks and circles of brass, and so they are served by them in their kitchens. One of these stone-pots takes heat, and boils, sooner than any pot of metal; and whereas the bottoms of metal-pots transmit the heat so entirely to the liquor within, that they are not insufferably hot, the bottom of this stone-pot, which is about twice so thick as a pot of metal, burns extremely. It never cracks, neither gives any sort of taste to the liquor that is boiled in it; but if it falls to the ground, it is very brittle; yet this is repaired by patching it up: for they piece their broken pots so close, though without any cement, by sewing with iron-wire the broken parcels together, that in the [illegible]es which they pierce with the wire there is no[illegible] least breach made, except that which the w[illegible]oth makes and fills. The passage to this min[illegible] very inconvenient; for they must creep into [illegible] for near half a mile through a rock, that is so hard that the passage is not above three feet high; and so those that draw out the stones, creep all along upon their belly, having a candle fastened in their forehead, and the stone laid on a sort of cushion made for it upon their hips: the stones are commonly two hundred weight.

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* Bourrit, Glaciers, iii. 120.

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* Chiavenna.

"But having mentioned some falls of mountains in those parts*, I cannot pass by the extraordinary fate of the town of Pleurs, that was about a league from Chavennes, to the north in the same bottom, but on a ground that is a little more raised. The town was half the bigness of

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* Rather of fragments and avalanches; and the partial ruin of Chiavenna, in the 14th century, by the fall of a cliff: p. 75.

Chavennes; the number of the inhabitants was about two and twenty hundred persons, but it was much more nobly built; for besides the great palace of the Francken, that cost some millions, there were many other palaces that were built by several rich factors, both of Milan and the other parts of Italy, who liked the situation and air, as well as the freedom of the government of this place; so they used to come hither during the heats, and here they gave themselves all the indulgences that a vast wealth could furnish. By one of the palaces that was a little distant from the town, which was not overwhelmed with it, one may judge of the rest. It was an outhouse of the family of the Francken, and yet it may compare with many palaces in Italy; and certainly house and gardens could not cost so little as one hundred thousand crowns. The voluptuousness of this place became very crying; and Madame de Salis told me, that she had heard her mother often relate some passages of a protestant minister's sermons, that preached in a little church, which those of that religion had there, and warned them often of the terrible judgments of God which were hanging over their heads, and that he believed would suddenly break out upon them. On the 25th of August, 1618, an inhabitant came and told them to be gone, for he saw the mountains cleaving; but he was laughed at for his pains. He had a daughter, whom he persuaded to leave all, and go with him; but when she was gone out of the town with him, she called to mind that she had not locked the door of a room, in which she had some things of value; and so she went back to do that, and was buried with the rest: for at the hour of supper the hill fell down, and buried the town and all the inhabitants, so that not one person escaped. The fall of the mountain did so *fill* the channel of the river, that the first news those of Chavennes had of it, was by the failing of their river; for three or four hours there came not a drop of water, but the river wrought for itself a new course, and returned to them. I could hear no particular character of the man who escaped, so I must leave the secret reason of so singular a preservation to the great discovery at the last day, of those steps of Divine Providence, that are now so unaccountable. Some of the family of the Francken got some miners to work under ground, to find out the wealth that was buried in their palace; for besides their plate and furniture, there was great store of cash and many jewels in the house. The miners pretended they could find nothing; but they went to their country of Tyrol, and built fine houses, and a great wealth appeared, of which no other visible account could be given but this, that they had found some of that treasure."

Mr. Coxe, in his interesting description of Swisserland, after a short account of this event, adds the following observations:

"I walked over the spot where Pleurs was built: parts of the ancient walls, and the ruins of a country-house, which belonged to the Franchi, the richest family in the place, are the only remains of its former existence; and these would not be noticed by a passenger. A peasant, who has a cottage close to the ruins, pointed out to me every place, as it had been explained to him by his grandfather. He showed me where stood the churches and principal houses, the channel through which the river then flowed, and where the bridge was constructed. He informed me, that in digging, several dead bodies had been found; particularly the bones of a priest, covered with shreds of garments, which indicated that he was employed in divine service when the rock overwhelmed the town. Household utensils are frequently dug up: the other day, several corpses were discovered, and on the finger-bone of one were a silver and two gold rings. Vineyards, chesnut-trees, and houses, cover the spot where this unfortunate town was once situated."

Diableret, 1714.

In 1714, a great part of the mountain Diableret fell. It was on the 23d of September, between two and three o'clock in the afternoon, and during the calmest weather, that the summit of this mountain fell in an instant, and covered more than a league of fertile land. Of 140 huts there only remained 40; and where the others stood, there is at present a bed of stones, about 30 yards in thickness. Four torrents were stopped, or changed their courses, and now terminate in lakes. There perished under the ruins of this mountain, eighteen persons, near one hundred cattle, with a great number of sheep, goats, and swine. Those who saw this disaster, say that it happened in a moment; and at the same time there rose whirling clouds of dust, which darkened the air like a sudden fall of night, and so much covered the neighbouring pasturages that they were obliged to withdraw the cattle. Even the adjacent mountains were wounded by the fall, which lasted for twenty-four hours. Some pretended that fire and smoke were seen; but the former arose from the collision of the siliceous fragments, and the pretended smoke was only dust; while the smell of sulphur arose from the pyrites.

To this account of honest Grouner, Bourrit has added, as usual, some picturesque circumstances.

"This ruin happened on the 23d of September; the weather was calm, the sky clear; the cattle were feeding peaceably under the shadow of these rocks; the goats, sheep, and lambs were playing in the pasture. The shepherds and shepherdesses were diverting themselves with innocent games; nothing happened to forewarn them of their terrible fate, when the mountain suddenly fell, and buried under its ruins shepherds, cattle, pasturages, and huts. The fragments of the rocks, which extended for two leagues; the smoke, which covered the sky with thick darkness; and the horrid noise, which the neighbouring mountains increased by deep and repeated echoes; all seemed to announce total ruin to the vicinity. The surprise, the terror, the lamentable outcries of men and quadrupeds, the disordered and tumultuous flight of birds, spread the alarm to a distance; and all fled from places which they could no longer know, and where they could not hope for safety. This terrible ruin destroyed considerable woods, which served as ramparts against the avalanches of snow, at present so dreadful and destructive. The rivulets which came from the mountain have lost their course, and no longer exist; so that the pasturages are become deserts, which only remind the spectator of this sudden ruin."*

This author also informs us, that, at the time of the earthquake at Lisbon, many mountains were seen to shake in the Vallais, which has remained subject to earthquakes since that period; and the town of Brigue suffered considerable damage. But in 1751, another mountain fell; and the account of this disaster shall be given in the words of Saussure; after premising that this mountain was situated not far from Passy, between Sallenches and Servoz.

Mountain near Servoz, 1751.

"Near this summit was situated a mountain, which fell in 1751, with so dreadful a noise, and so thick and dark a dust, that many people believed that the world was at an end. This black dust passed for smoke; eyes, distracted with fear, saw flames in the midst of the whirling smoke: and intelligence was received at Turin, that a terrible volcano had burst forth in the midst of these mountains, so that the king sent a celebrated naturalist, Vitaliano Donati, to verify that report. He came with great diligence, before the rocks had completely fallen, so that he was witness of a part of that event. He gave the king a memoir of his observations: and a brief account is contained in a letter to one of his friends, of which I possess the original, dated 15th October, 1751, and of which a translation follows:

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* Grouner, Glac. de Suise, Paris, 1770, 4to. p. 138. Bourrit, ii. 98.

'I left Turin on the 16th July, and only returned within these few days. I was in the valley of Aosta; and I was in hopes of being in Venice in September and October. But I was obliged to turn back, and make a tour of 250 leagues in the mountains, to observe the pretended new volcano, according to an order which I received from his majesty. I confess, that though I doubted the truth of the fact, nevertheless, hoping that I had deceived myself, I hurried with extreme pleasure to observe so extraordinary a phenomenon. After having travelled four days and two nights without halting, I came in front of a mountain all covered with smoke; and from which were incessantly detached, by day and by night, large masses of stone, with a noise perfectly like that of thunder, or of a large battery of cannon; but still louder and more terrible. The peasants had all retired from the vicinity; and did not dare to look at this ruin, but at the distance of two miles, and even farther. All the neighbouring fields were covered with a dust much resembling ashes; and in some spots this dust had been carried by the winds to the distance of five leagues. All said that they had seen, at intervals, a smoke which was red during the day, and accompanied with flames at night. These observations led people to believe that it was a volcano. But I examined the pretended ashes, and only found a dust composed of brayed marble: I attentively observed the smoke, and neither perceived flames, nor any smell of sulphur; nor did the rivulets, nor fountains, which I examined with care, present the least appearance of sulphuric matter. Thus persuaded, I entered into the smoke, and, though quite alone, went to the brink of the abyss, where I saw a large rock dart into that abyss, and observed that the smoke was only dust, raised by the fall of the rocks; the cause of which I soon after sought for and discovered. I saw that a great part of the mountain, situated above that which had fallen, was composed of earth and stones, not disposed in beds, but confusedly heaped together. I thus perceived that the mountain had been subject to similar falls; at the end of which the large rock, which fell this year, had remained without a support, and with a considerable projection. This rock was composed of horizontal beds, of which the two lower were of slate, or rather of fragile schistose stone, and of little consistency; while the two beds beneath these were of a marble, like that of Porto Venere, but full of rifts which crossed the beds. The fifth bed was wholly composed of slate, in vertical leaves, entirely disunited; and this bed formed all the upper part of the fallen mountain. Upon the same level summit there were three lakes, of which the waters penetrated constantly by the fissures of the beds, separated them, and decomposed their supports. The snow, which this year had fallen in Savoy in so great abundance as had never been seen in the memory of man, having increased the effort, all these waters reunited produced the fall of three millions of cubic fathoms of rock; a mass sufficient to form a large mountain. In the narrative which I have written of the fall of this mountain, and which I sent to his majesty, with a view of the mountain, I have given a more detailed account of the cause and effect of this ruin; and I foretold that it would cease in a short time, as has actually happened; so that thus I have extinguished a volcano."

Saussure proceeds to inform us, that the ruins of this mountain are situated to the north-east of the village of Servoz. Besides the sandstone already described*, Saussure observed rocks of grey marble, and fragments of slate.

Rosenberg, 1806.

Such are some of the most remarkable examples of this phenomenon. In 1806, the mountain of Rosberg, or Rosenberg, near the town of Arth, fell down, and buried a considerable tract of country, with some inhabitants. A detailed account of this event was published at Paris, with three plates, representing, 1. the town of Arth, the neighbouring country, and the profile of the ruin; 2. the same scene in front, with the extent of the fall; 3. the lake and tower of Lawerts, with Roggiberg and Rosenberg†.

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* Dom. II. Mode xiv.

† *Derniere relation du triste désastre, causé par l'eboulement d'une partie du Roggiberg, et du Rosberg*; de trente pages d'etendue, *accompagnée de trois gravures, proprement terminées en noir, de* 10 *pouces de haut, sur* 15 *de large. Chez Villequin, march. d'estampes, grande cour du Tribunat, No.* 20. 9 *fr.*

La premiere represente le beau bourg d'Arth, les campagnes qui l'avoisinent, et le profil du l'eboulement: La seconde, l'immense catafalque, et triste tombeau, d'une partie des habitans, de la vallée d'Arth, et l'eboulement vu de face. La troisieme, le lac et la tour de Lawerts, le Roggiberg, et le Rosberg.

George Cooke sculp

Vesuvius

DOMAIN XII.

VOLCANIC.

◆

Volcanoes numerous. THE volcanic rocks may be said, with the German mineralogists, to be of the most modern formation, as every new eruption of about one hundred and fifty volcanoes scattered over the face of the globe, must produce new rocks of this description. That there are also volcanoes at the bottom of the sea, we know, from the ejection of new islands in the seas of Greece; and in the Atlantic near Iceland, and the Azores. It may therefore be considered as a most rational conclusion, that, as the ocean occupies two-thirds of this globe, numerous volcanoes may exist at such depths, that their effects are wholly unperceivable. Dolomieu seems to have demonstrated that the matter, which supplies the prodigious eruptions of volcanoes, must lie at an immense depth beneath the crust of the earth. This position may be argued, 1. from the surprising extent of earthquakes, felt from Lisbon to Scotland, a space of 15 degrees, or about 1000 British miles. 2. From the prodigious quantity of matter ejected in the course of ages; from the comparatively small craters of Etna, for example, whole mountains, nay territories have issued; which, if drawn from a space near the surface, the mountain must long since have sunk into its own abysses. 3. From the nature of the lava, which, in some instances, has burst through the superincum-

Depth of fuel.

bent masses of granite, itself regarded as the fundamental rock.

Candour necessary.

As it is foreign to the nature of this work to examine with much attention the theories of volcanoes, it shall only be observed that the French authors, in treating the origin of basaltin and amygdalite, seem to be rather too much attached to the volcanic influence; yet we, on the other hand, seem to be too violently prejudiced against the admission of that influence. Prejudice, on either side, is not only ridiculous, as the subject is of no importance to human life or happiness, but as a direct contradiction to the very spirit and nature of philosophy, which ought to examine any topic with complete candour and impartiality; nay, a writer who means sincerely to serve the sacred cause of truth, which must in the end ever be victorious, would rather, for a season, support an opinion the most opposite to prejudice, that the light may as usual be struck out by the collision of contending powers.

Many extinct.

When we consider the great number of

volcanoes that are still active on that third part of our planet which consists of land, is it not most rational to suppose that many may have become extinct? Strabo informs us, that Vesuvius had been a volcano at a remote period; while its first eruption is commonly ascribed to the reign of Titus, near a century after the time of that author[*]. The volcanoes of Auvergne seem to have been relumed for a short period, in the time of Sidonius Apollinaris, whose *culmina* can scarcely be applied except to the summits of mountains; for the tops of houses would be foreign to his emphatic and alarming description. Auvergne alone has indeed convinced every Neptunist, who has visited that interesting country, that volcanoes may become extinct; and may, perhaps, again surprise the unbeliever with an unexpected appearance. The wonderful volcano of Jorullo, in New Spain, burst out about half a century ago, in the midst of a fertile and luxuriant plain; but, as has been observed, in the precise line of direction of the other volcanoes in that country; whence it has been argued, that there is a chasm, at an amazing depth, filled with subterranean water and combustible materials. For the American volcanoes are generally very distant from the sea*, and their eruptions of mud can only be imputed to subterranean waters, often very extensive; as is observed from digging wells in the north of Italy, near twenty miles around Modena, where, on arriving

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[*] Lib. v. This remarkable passage may be thus translated:

"Here arises the mountain of Vesuvius, inhabited through all its delicious fields, the summit alone excepted, which spreads into a barren plain, displaying ashes and deep caverns formed of burnt rock, as the colour indicates, and abrasions by fire; whence it may be conjectured that this mountain was formerly in a state of efflagration and presented fiery craters, which became extinguished when the materials were exhausted." He proceeds to state, that the fields near Etna were equally fertile. The streets of Herculaneum were paved with lava.

See also, Strabo, lib. i. p. 158. edit. Siebenkees, for a volcano, soon extinct, near Methone, which ejected a hill near a mile in height, and rocks like towers.

Pindar describes Etna, which is unmentioned by Homer, a proof that his geographical knowledge did not extend as far as Sicily, and that the received interpretations are false.

Chasms.

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* Even those of the Andes are from eighty to one hundred miles; so that a late writer is much mistaken when he supposes them near the ocean, and influenced by sea-water instead of subterranean lakes.

at a certain crust, the water gushes out with prodigious violence. If this vast chasm, therefore, be covered with such a lasting shell of fertile land, it is easy to conceive the existence of similar cavities in many parts of this globe. For we are not to imagine that the immense mass which forms the nucleus, and which from its gravity would appear to be iron, presents a uniform surface; but may, on the contrary, bear fissures deeper than the ocean, and asperities or precipices higher than mountains. Hence the grand observation of Saussure, his *refoulements**, may be construed into a subsidence of the beds at one extremity, owing to irregularities on the surface of the nucleus, and which of course elevated them at the other extremity; while the secondary rocks, the level or horizontal of Werner, finding the asperities already filled, of course retain their regular formation.

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* "Examiner en général si les couches presentent des indices de soulevements, ou de refoulements violents, qui aient changé leur situation primitive; ou si, au contraire tous, et les redressements même des couches, peuvent s'expliquer par de simples affaissements." § 2314.

But if, with Dolomieu, we conceive that this planet only presents a shell spread over a fluid centre, it would be difficult to explain why this central lava should only burst forth in particular spots and directions; for it might equally appear in every portion of the globe. Theories, which only afford sublime speculations on the vast varieties of nature, and the infinite power of the ineffable Creator, cannot be greatly blamed, even when *they do not* lead to incontestible conclusions; and it is hoped that an inference arising from the preceding considerations may be hazarded; namely, that volcanoes owe their origin to fissures, more or less extensive, in the very nucleus of our planet; and that these fissures always remaining, the causes of eruption may be withdrawn or renewed. This theory might reconcile most of the doctrines on the subject, except the puerile ideas of those Wernerians who have never visited volcanic countries, and who impute these wonderful efforts of nature to a few beds of coal! But coal or bitumen would easily be traced in the currents of lava, while no such appearance has ever struck the most attentive and rigid observers; and a large bed of coal, near Dysert, has been on fire since the days of Buchanan, the poet, without even the mockery of a volcano. An idea, which tends to degrade the power and magnificence of nature, can never be true; and, when we seriously reflect on the daily circumvolution of this planet, it is impossible to find a greater miracle. In complicated scenes there must be complicated causes; but does not the grand exhibition of volcanoes arise from natural gunpowder?*

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[*] The common subterranean noise of Cotopacsi, may be heard at a distance of the space between Vesuvius and Dijon, in Burgundy, according to Humboldt: and Bouguer, p. lxvi, informs us that the same volcano has thrown stones, of 8 or 9 feet in diameter, to the distance of 9 miles.

Werner seems not to have formed the most distant idea of a volcano; and his pseudo-volcanoes are much beneath even that name, having scarcely a faint resemblance of a volcano.

According to Brochant, ii. 633, one eruption of Etna covered a space of more than 50 leagues in circuit, with a bed of volcanic sand 12 feet thick.

The existence of such chasms being once admitted, it would be easy to account why basalt always appears in volcanic countries; since, even on the supposition of the French mineralogists, particularly Patrin, these chasms must have supplied volcanic materials, under the primeval waters, or what may be called a state of chaos; for Patrin supposes that basaltin, compact or columnar, but especially the latter, may be the produce of submarine volcanoes, the matter being suddenly congealed, and brought to a most compact form by the prodigious pressure of the ocean. Daubuisson, a rigid and determined Neptunist, after visiting Auvergne, was inclined to suppose, as already mentioned, that the basaltin on the summits of the German mountains was a volcanic remain of inconceivable antiquity. Reuss also concluded that the basaltic summits of Bohemia were only fragments of a mass, which had once clothed a prodigious territory. In like manner, caps of mountains sometimes present masses of sandstone, or limestone,

Basalt.

Basaltic summits.

while none exist in the adjacent country. Whether this effect could be produced by currents at the bottom of the primeval waters (and similar currents continue to be observed in many seas), which, by their continual action, abraded the lower parts, without reaching the summits of these then submarine hills; or from whatever other cause this effect may have proceeded, must for ever remain among the inscrutable secrets of nature, which despise the puny efforts of human intellect. Perhaps it may simply arise from the circumstance that these portions, sometimes from their position, and sometimes from internal causes, may have been harder than the rest of the mass, and thus have remained like some large fragments of granite, after the softer parts had wasted away. However this be, we must never, in geological discussions, forget the amazing power of time, which enables the water to destroy the hardest rocks; and which, though important in the short period of human life, may be said to be nothing, in the eternity of Him, with whom a thousand ages are but as one instant.

Effects of water.

In general, the effect of fire only is considered in volcanoes; but the curious volcano of mud in Sicily, and the *muddy* eruptions of the Andes, should excite more attention to the agency of water. If we conceive the volcanic chasms, containing, as already mentioned, reservoirs of water, as well as of inflammable substances, to be in the nucleus of the globe; and that nucleus to consist of iron, mingled at least superficially with its usual *attendant silex*, the ferruginous nature of lava can easily be explained, as arising from an abrasion of the nucleus by the water. For, passing the minuter appearances, which only excite curiosity, and are exceptions, not rules;

Iron and silex.

all lavas may be said to consist of iron and silex; the most common being the black, of melted siderite; while the others, of a grey colour, have a base of silex in the

Felspar.

form of felsite. But felspar is a name of far too general acceptation; and may probably, in the progress of mineralogy, be divided into six or more denominations, to be determined by future analyses: for its extent and importance are prodigious, constituting two-thirds of granitic mountains, and appearing in many other forms, which seem to indicate a substantial difference in the siliceous rocks, now included under the vague name of felspar.

Lava.

These introductory observations have thus conducted us to the more immediate object of this work: the consideration of the lavas themselves.

Compact lava.

The existence of compact lava, forms one of the most curious questions between the Volcanists and the Neptunists. In strict impartiality, the observations of Mr. Kirwan, the chief defender of the Neptunian system, shall be admitted at full length, more especially as they may lead to very important observations.

Mr. Kirwan's opinion.

"By compact lava, volcanic writers denote an earthy substance, which, after having been fused, but not vitrified, becomes, on cooling, compact, close, and solid.

"Whether this degree of solidity is such as totally to exclude that evidently porous and cavernous structure, which cellular lava presents, is not perfectly agreed upon.

"Those who are guided by observation on modern and undisputed volcanic torrents, allow that no lava absolutely compact, and destitute of pores in an extent of more than a few square inches, is ever found. Thus Mr. Bergman defines compact lavas to be 'those which, though not absolutely destitute of cavities, *yet* contain so few, that they may be cut into slabs with an almost entire surface, and polished like marble,' 3 Bergm. p. 201. To this definition, M. Dolomieu, in his notes on Bergman's dissertation, makes no objection; from which we may conclude, that in a small extent, such as that of common marble slabs, they never exhibit an uninterrupted surface. This last mentioned philosopher, indeed, having unfortunately wished to comprehend, in his definition of compact lava, stony masses, not found in modern and undisputed beds of lava, but in supposed ancient currents, found himself much embarrassed: 'there is,' says he, 'such uncertainty in the characters of compact lava, that independently of local circumstances, the most experienced eye may be deceived*.' Yet these circumstances not properly attended to, are those which have seduced him into the most palpable mistakes.

"Gioeni, though in many instances misled by Dolomieu, yet acknowledges that lava, so compact as to be totally destitute of pores, is not to be found. Litholog. Vesuv. p. 85†. Padre Torre, who, independently of any system, has candidly and impartially examined the products of Vesuvius, expressly denies the existence of lava destitute of pores; none other but the porous being found of modern date‡. Galeani, in his catalogue of the lavas of Vesuvius, drawn up in 1772, hardly mentions any compact lavas. Gioeni, in his catalogue, entirely omits this distinction; and M. Dolomieu acknowledges, that not a single specimen of compact lava is to be found in the cabinet of Prince Biscari.

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* Isles Ponces, 171.

† (It is 157; but not expressly.—P.)

‡ Ponces, 174.

"Those, on the other hand, who, guided by system, bestow the name of lava on stony masses which they suppose to have anciently flowed, either from real still subsisting, or imaginary ancient extinct, volcanoes, find compact lava entirely destitute of pores, very scarce indeed in the supposed currents from modern, *but in great* plenty in those which they ascribe to their fictitious volcanoes now extinct, as well as in the very bowels of those volcanoes.

"Gioeni after telling us, from Dolomieu, that compact lava occupies the centre of the beds of lava, and porous lava the upper part, acknowledges that this gradation seldom takes place: 'few, however,' says he, 'are the visible currents of lava on Vesuvius, in which we meet this gradation.' It seems he should rather have said, none; for, some lines after, he tells us, 'that modern volcanoes have lost the power of producing any*.' The detached masses that pass for compact lava, he acknowledges to have been ejected in their solid form, by the explosive power of the volcano; and consequently they are not real lavas, but rather natural stones, torn from the sides of the mountain†. M. Dolomieu tells us, that compact lavas are stones, which, after having been melted, reassume their natural state and appearance, without any change in their external or internal properties, or scarce any change‡; and that some are perfectly compact (that is, destitute of pores); namely, those that are buried under, not other lavas, but under an entire and immense volcano§; he therefore gives up the idea of finding these, not only in the beds of modern, but even in those of extinct ancient volcanoes. Hence he tells us, that they are much more common in extinct volcanoes; and that in Etna they do not constitute the one thousandth part of the whole; whereas, in Vivarois and Auvergne, they form whole mountains. Now most of these ancient volcanoes of the Vivarois, appear to me, and many others, to be mere creatures of imagination; and consequently, until the substances they contain are proved to have been in fusion, no definition, grounded on the appearances of these substances, can pass for that of real compact lava*.

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* Lithol. Vesuv. p. 47.

† Ibid. 51.

‡ Dei prodotti Volcan. p. 162. Ponces, 170, &c.

§ Ibid. 179.

"In beds, however, of real undisputed lava, some parts are found, that having been pressed by the superincumbent weight, are more compact than common porous lava, and these, comparatively to the former, may be called compact; but scarcely more than a few square inches of their substance is destitute of visible pores.

"Their colour is brown, yellowish, reddish brown, bluish, or black, more rarely grey. Their lustre 0,1. Transparency 0,1.

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* (See, on the contrary, the remarks of another Neptunist, Daubuisson, in Dom. I.—P.)

"Their fracture, earthy, or fine splintery, more rarely foliated, and presents small internal pores, if of sufficient size, in some part of their substance.

"Hardness, from 7 to 9. Specific gravity, 2,75 to 2,88.

"Much circumspection is requisite, in framing a description of compact lava, from a view of the specimens brought to us from volcanic countries; as they are all collected by persons who take indiscriminately from real, and from supposed, volcanic currents, even from mountains in which no volcano ever existed.

"To form a true idea of these lavas, we should attend to the following circumstances:

"1st. That the heat of most volcanoes (I exclude those that for the most part produce only vitrified substances) seldom reaches 100 degrees of Wedgewood; the proof of which is, that almost all real lavas, whether cellular or compact, are vitrifiable at that degree. Since, therefore, they were not vitrified in the volcano, it is plain that in it they did not attain that degree; 90 or 95 degrees may then be assumed as the average heat of most volcanoes.

"2d. In this heat, many stones of the argillaceous genus, as traps, hornblendes, and argillites, undergo a change; for they alter their colour, become porous, assume a porcelain grain, and consequently begin to vitrify, as I have found on repeated trials; but they never flow in this heat, nor consequently form a lava; but bitumen will flow in this heat, and even in one much inferior, and be decomposed. If, therefore, the argillaceous stones be mixed with, and drenched in bitumen, they will be softened by it, and flow with it; and where the air, erupting both from them and the decomposing bitumen, has most liberty to escape, it will tumify, burst through the liquid mass, and form cellular lava; but where it is more compressed, less of it will be disengaged, and the lava will be compact, and resemble in some degree the original stone of which it is formed.

"3d. Stones of the siliceous genus undergo no change in this heat, not even schorls or felspars; and hence, though immersed in the fiery torrent, they cannot with propriety be called lavas; as they are not even softened by the mixture of bitumen, as stones of the argillaceous genus are.

"Between siliceous and argillaceous stones there are many gradations, and various mixtures, which must occasion corresponding varieties in the effects which heat, and various other circumstances, may produce. It is sufficient here to establish the principles on which most of them may be explained. Compact lavas abound in heterogenous substances, which have either not been fused, or only partially fused, or scorched, or decomposed by heat, as felspar, schorls, garnets, zeolites, &c. Every volcano has some that are peculiar to it. Thus the lavas of Vesuvius abound in that called white garnet, and which I call Vesuvian; those of Etna abound in felspar, &c.

"Hence we must exclude from the rank

of lavas, all stones which do not appear, either from their external characters or local circumstances, ever to have been softened by heat; and consequently all those detached pieces which are ejected at the beginning of an eruption without fusion, and many others which volcanic collectors enumerate among compact lavas, merely from having found them in the vicinity of volcanoes. Thus M. Dolomieu, Lipari 85, reckons among volcanic stones one, in the interior of which he distinctly perceived a leaf of sea-weed. Few indeed are the stones contained in his catalogue, which can be deemed really volcanic: and p. 70, of the same treatise, he tells us, that the lava which burst from the sides of Etna, in 1669, had for its basis a granite, no way altered; but when he expressly treats of the products of Etna, he tells us, *L'Etna paroit n'avoir jamais traité le granite.* The mistakes of this great man, for such I certainly hold him, have had so wide a spread, and have misled so many who have not had an opportunity of viewing volcanic countries, that I feel myself necessitated to detect them; a liberty which, I am persuaded, his candour and love of truth will readily induce him to excuse.

"All real lavas, except those of the vitreous kind, affect the magnetic needle, unless the iron they contain be much oxygenated, as it often is in those of a red colour; but even these are frequently magnetic, by reason of the schorls embodied in them.

"The component ingredients of lavas are various, according to the nature of the original stones, and the accidents they meet with in the liquified state. M. Dolomieu found them to contain from 40 to 60 per cent. of silex, from 16 to 3 of magnesia, from 5 to 1 of lime, and from 6 to 25 of iron. Ponces, 184."*

These reflections are certainly cogent, and worthy of the sagacious author, who has rendered great services to the science:

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* Kirwan, Min. i. 404.

nor must we, in the modern spirit of ingratitude, nor even of

> Th' unwilling gratitude of base mankind,

forget the state of mineralogy at the time he wrote, because superior illumination has since been thrown on many topics.

Other opinions.

On the other side, the works of Dolomieu on the Lipari Islands, on those called Ponces, near the Gulf of Naples, and on the volcanic productions of Etna, were written before he had attained much experience in lithology. This truth *lamentably* appears from the latter production, where two or three passages demonstrate that he did not even know what granite is*; yet we are told that exact nomenclature, and the precise knowledge of particular stones, are not necessary in geology; which is as

Dolomieu inaccurate.

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* In p. 201, he tells us that the *base* of granite, consists of massive felspar: and p. 257, he mistook a mixture of schorl, felspar, and chrysolite, for a granite. Equal errors may be found in many books of geology; a study which totally depends on a previous acquaintance with petralogy and lithology. Dolomieu was a military man, who at an advanced age entered on this difficult study.

much as to say, that Botany can only be studied in the roots, or Zoology from the legs of animals; that History may be studied in a book of chronology; or that, in short, any science may be attained with complete inattention to its chief objects. For a laborious study, and even the most nice discrimination of lithologic characteristics, is indispensable; otherwise the keystone may happen to be the weakest, and the whole edifice may sink in ruins. The treatises of Dolomieu on different rocks, published some years after in the Journal de Physique, though tedious, prolix, and ill-digested, like all his writings, are the best and most scientific of his productions. But, on the other hand, our celebrated mineralogist is certainly mistaken, when he asserts that siliceous stones undergo no change in the heat of volcanoes; for the white or grey lavas, with a base of felspar, are among the most common, and are sometimes interspersed with mica, so as to show that the parent rock was a felspar mixed with that substance; while the mottled or dotted appearance of the lava is such as never occurs in any natural rock. The quantity of potash recently discovered in felspar, sufficiently accounts for its *fusibility*. Nor, so far as the perusal of most works on the subject can conduct to an opinion, is the power of volcanic heat to be computed from a few examples; while it is sometimes, on the contrary, demonstrable to be very intense.

Compact lava dubious.

It is truly singular that, in the state of a science so much advanced since the time of Dolomieu, specimens of compact lava do not abound in every cabinet; and that the subject has not been completely investigated; but attention has been diverted to crystallography, which may be called the entomology of the science, while the grandest objects of nature are neglected. Dolomieu positively allows that what he calls the basaltic columns, chiefly observable on the eastern side of Etna, are composed of a lava, "of which the most compact morsels are not exempt from some little round pores, easily discoverable with a lens*." In this they differ from basaltin, one of the most compact substances in nature; though Werner himself marks its contexture as cellular, or vesicular. Even in the purest substances, as glass, the marks of fusion by heat remain in little globular cavities. But that the question has not been examined with due care and sagacity, will appear from another observation.

Basaltic columns compared with lava.

The beautiful forms of basaltic columns have, on a first review, been compared with the fissures arising from the desiccation of starch, and some argillaceous substances. But the comparison is in fact of the most careless kind, and arises from a distant resemblance, as if a trunk of a tree were compared with a Corinthian column. The accurate eye of Pictet has observed, and he has engraved a most distinctive characteristic of the columns of the Giants causey, unobserved by all writers on the subject; which is, that the joints of the columns are not only inserted in each other by hemispherical protuberances and concavities, but that the corners of one joint rise into what may be called triangular mortices, nicely adapted to receive the next joint, which appears as if cut for that purpose*. Patrin showed me, at Paris, and has engraved in his mineralogy, specimens of Siberian emerald, with similar protuberances and concavities; the former sometimes admitting of being detached when it assumes the form of an irregular oval. But no one has doubted that these emeralds are crystallised by water; and Patrin makes the curious observation, that when they are broken in the mine, they are soft as an apple, "and the two fractures are covered with a fluid of an unctuous appearance, and penetrating smell, which evaporated quicker than a drop of ether:"† but exposure to the air for a few hours, rendered them quite hard. It might hence appear, that to carry the chemical analysis of mineral substances to the greatest perfection, means should be contrived to preserve their natural softness while in the bowels of the earth, either by instant immersion in naptha, or by other means of excluding the air. This simple attention might perhaps lead to very curious and important discoveries; which might gradually conduct us to rival nature herself in the combination of the most precious minerals.

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* Etna, p. 192.

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* Da Costa, however, had observed and engraved the same appearances, in 1757. See his Fossils, p. 256, and the plate.

† Min. ii. 33. From this and other circumstances, detailed in various parts of his work, Patrin argues for a kind of mineral life. He might have rather said that God fills all space.

Mens agitat molem, et magno se corpore miscet.

To return, as the crystallisation of emeralds has never been denied, so it would appear that the yet more curious and refined articulations of basaltin cannot be ascribed to any other cause. The columns of sandstone, and other substances, and it is suspected even the columnar lava of Etna and other volcanoes, cannot be compared with this consummate, and, so to speak, artificial architecture; for nature is the art of God. A prejudiced eye would find identity; but if no such forms be observable in the columnar lavas, a rational argument would arise that the basaltic columns have a different origin. Such is the nature of lithology, that a very minute difference sometimes constitutes a wide distinction; and Werner's system of external characters rests on little tints and shades, for which his sagacity found expressions; while many of them have been known before by experienced miners, who felt and knew what they could not express; as a shepherd cannot impart the knowledge by which he can discern any one sheep among a thousand, a trivial circumstance in pastural countries.

Origins of basaltin.

The final opinion of Dolomieu, in which he is joined by Spallanzani, who visited the volcanic regions of Italy with great care, though not perhaps with a sufficient experience in lithology, was that basaltin may be produced either in the humid way, or by volcanic fire. In submarine volcanoes, if we listen to the French mineralogists, it might be ejected by heat, and crystallised in a more compact and beautiful form than it assumes when it only enters the confines of the sea. It always seems to have another singularity, which must not be forgotten, namely, an arid and dead appearance, ranking it with the stones called by the Italians *pietri morti;* while other substances indescribably belong to what is called the living rock.

In the opinion, therefore, of the greatest mineralogists, we are only authorised to consider as compact lavas those which have very small pores; for volcanic basaltin, though admitted by Dolomieu and Spallanzani, is exposed to all the tempests of Neptune and his followers. Masses and columns of basaltin, brought from well known lavas of whatever antiquity, would alone form a barrier against their attacks. A strict examination of the supposed basaltic columns of Etna, where its vast lavas enter the sea, might also lead to some conclusions, whether the opinion of those philosophers be just, who argue that basaltin is always a volcanic product, its compactness arising from its formation under the primeval waters, like most other rocks, at a period when the power of crystallisation was more vigorous, as appears from all the other primitive substances; and nothing can be more rational than to infer that volcanoes not only existed in that state of the globe, as they are now known to exist in the vast depths of the ocean; but that they must have been far more numerous, and of greater power, than in the subsequent tranquil state of the elements[*].

Ferrara's system. Ferrara, the intelligent professor of natural philosophy in the university of Catania, has just published a learned work on the volcanoes of Sicily, and the adjacent isles[†]. This treatise is certainly important in the history of mineralogy, as it seems to decide some points which were before doubtful, and throws fresh light on many of the most interesting topics of the science. After a long and patient investigation of all the lavas in Sicily, and the neighbouring isles, he has opposed the opinions of Dolomieu; whom he justly regards as a cursory visitor, who would have retracted many of his remarks, if he had simply twice visited the same objects, the first ideas being often corrected by the second. After a sedulous attention of many years, Ferrara denies that there are any prisms whatever, in any lava which has erupted since Sicily emerged from the primeval ocean. But he is at the same time as decided in his opinion, that all basaltic columns are the product of primeval submarine volcanoes. This position he does

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[*] In his grand and surprising course of lectures, 1811, Dr. Davy is said to have produced an artificial volcano, being a hillock of clay enclosing a mixture of potassium, iron, and lime: on pouring water, smoke, flame, and lava, issued from the crater. The earths, he conceives, may exist in a metallic state in the centre of the globe, and, combined with water, may become earths, and supply new continents.

[†] *I Campi Flegrei della Sicilia, e delle isole che le sono intorno; o Discrizione Fisica e Mineralogica di queste Isole. Dell' abate Francesco Ferrara, Professore primario di Fisica nella Regia Universita di Catania, Dottore di Filosofia e Medicina, e Socio di varie Academie. Messina, dalla Stamperia dell' Armata Britannica.*

Submarine volcanoes.

1810, 4to. "The Burning Fields of Sicily and the surrounding isles, or a Physical and Mineralogical Description of these Islands, by Abbé F. Ferrara, principal Professor of Natural Philosophy in the Royal University of Catania, Doctor of Philosophy and Medicine, and Member of several literary Societies. Messina, from the Press of the British Army, 1810." pp. 424.

not seem to have borrowed from the French mineralogists, but to have adopted from his own observation. For this inference, which to some may seem arbitrary, and even visionary, is founded on an indubitable fact that currents of lava, perfectly identic with that of the historical and later ages, are found covered, and often even alternating, with products universally allowed to have been deposited by the primeval waters, such as thick beds of chalk and limestone, sometimes compact, sometimes conchitic.

Construction of Sicily.

By his account, and the mineralogical map which accompanies his work, the whole of Sicily appears to be calcareous, except the mountains of Peloro, in the north-east corner, which consist of grey granite, often covered with a bed of limestone. In that quarter, near a hundred mines were formerly wrought, producing abundance of silver, copper, and lead. The limestone of Sicily is often in the form of what he calls *creta*, by which he does not seem precisely to understand chalk;

but perhaps that kind of earthy limestone, which appears under the Giant's causey in Ireland, and which has also been called chalk. In other parts there are extensive layers of keralite, which occasionally, by his account, passes into the beautiful agates and jaspers, for which Sicily is famous; as it is for its singular marbles, seemingly affected by the volcanic vapours. The chalk he regards as the base of Etna itself, which he considers as being entirely a volcanic mass of a hundred miles in circuit, ejected by the prodigious extent of internal fermentation, which since the creation has agitated Sicily and the adjacent isles and coast of Italy; and which must exist, as he infers, at a depth almost inconceivable*. The question of the intensity of volcanic heat, he regards as merely depending on circumstances, being sometimes great, sometimes moderate; and the quantity of liquid lava may be esteemed a standard of the activity of the fire. His estimate of volcanic products is the reverse

* P. 141, 409.

of that of Faujas, being extremely simple and confined; and he confirms the idea which I have long since advanced, that all lavas consist of siderite and felsite. The former, with Saussure and other writers, he calls *pietre cornee*, being a *corneus* of Wallerius[*].

The study of extinct volcanoes he considers as, perhaps, more interesting to the naturalist, than that of the active[†]. Not only has Vesuvius been repeatedly quite extinct for centuries; but even the tremendous and eternal Etna was quiescent from 1447 till 1537. The basaltic prisms, as already mentioned, he regards as the undoubted products of submarine volcanoes; and his account of their origin may more accurately be expressed in his own words.

Origin of basaltin.

"As a perfect dissolution is necessary in order to form perfect crystals, so a perfect fluidity is required in stony substances, that in their consolidation, after their dissolution by fire, they may assume the forms to which they have a natural tendency. It cannot be denied that many modern lavas have all the fluidity of which they are capable: what circumstance then has permitted the *ancient** lavas sometimes to assume the form of prisms, which is entirely denied to the modern?

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[*] P. 291, 343, 173.

[†] "Lo studio dei volcani ardenti non essere il solo che possa perfezionare la scienza; che quello degli estinti è, a certi riguardi, piu fecondo di lumi, e non meno del primo degno dell' attenzione, e della premura del Naturalista." *Disc. Prel.* p. iv.

"A lava which rises from the bottom of the sea, must be consolidated in a shorter or longer time by the cold contact of the water. The lava being thus amassed around the orifice, while the subterranean ferment continues, or is even augmented, the elastic vapours, acting from beneath, must break the upper surface, and occasion the lava to accumulate on itself. The sides, however, remaining always consolidated, at length the mass appears above the waters; and the crater which rises above the waves, communicating with the source of the fire, which cannot be inundated, may thus continue its *explosions*. In this manner were formed, even in our times, many isles in the Grecian archipelago; and in this manner must have been formed the Eolian isles, and other volcanic rocks around Sicily. Finally, when the efflagration ceased, the lava which formed the great mass upon the bottom of the sea, while it was surrounded on *all sides with* a thick arrect of the same matter (now cold and a very bad conductor of the internal fire, which ought to assume the temperature of the water), now enclosed, both beneath and above, with the same lava, remains in the internal gulf, in the most perfect fluidity that it can receive from fire, to which it has been so long exposed, and in a condition to suffer all the activity of the subterranean furnace. It is very probable that the lava in this recipient, having the necessary time, space, and tranquillity, cools slowly, and condenses under the forms to which its nature tends*. For what is crystallisation but the effect of a similar inclination of the more simple, similar, and attenuated particles of matter? It appears to me then that this tendency, being facilitated by the circumstances here indicated, explains the formation of prismatic lavas, without confounding them with the products of crystallisation."†

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* By this word he always understands, as he explains himself, the primeval submarine volcanoes.

He supposes, p. 289, that the rocks are rendered fluid by elastic vapours, *vapori elastici*; and, *from their resemblance to rivers*, are, *like them*, called *lavine* or *lave*. Does he refer to the Sicilian dialect? In pure Italian, *lavare* is to wash, or water.

As an example, he mentions the rock of Motta, which with those of the Cyclops he has also engraved, in the rude manner now practised in Sicily. He observes that, in this and other instances, the centre alone is in the prismatic forms, which are sometimes found enclosed in amorphous lava, identically the same with the columns, sometimes in tufa, and sometimes even in volcanic glass. But he seems never to have seen or observed the remarkable articulations, not only convex and concave, but strengthened by projecting angles and recipients, which were first noticed and engraved by Da Costa, and afterwards by Pictet, in their representations of the giants' causey. This striking characteristic, which seems unaccountably to have escaped most writers, can scarcely be ascribed to mere desiccation; but seems rather to rival the process by which nature produces regular rock crystals, in the vast caverns of the Alps, of enormous size, and weighing many tons.

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* "A similar combination, upon a very small scale, may have produced the few prisms which are found in the upper parts of Etna, and likewise in the Eolian Isles, not to mention Vesuvius."

Our author has shown that schistose substances, when melted by the volcanic heat, will reassume the same form. But what does he conceive to be the *natural tendency* of basaltin? The forms he describes, are not only the prismatic with articulations, but that of balls with concentric layers; and others, in which the prisms contract and meet in the centre, like the balls of pyrites found in chalk. But as iron often assumes the prismatic and globular forms, and even the radiated and concentric, he ought to have referred the whole to that metal, so predominant in siderite, which forms the base of these lavas.

† P. 319.

Columns of Sicily.

Other basaltic columns occur in Sicily at Vizzini, where the columns are articulated and a foot in diameter, but only a few feet high, curiously arranged on a curved basis; and they gradually become irregular, and pass into the amorphous lava. At the Motta, already mentioned, they are about two feet in diameter, partly vertical partly inclined. At the bottom of the colonade the peasants made an aperture, where, on introducing the hand, heat was perceived, and the hand smelled of sulphur. Above are great masses of sand, red drosses, and puzzolana; and he infers that the prisms are in the centre of the volcanic mass. It may be said indeed, that heat thus enclosed becomes inextinguishable; and he mentions that, two years ago, the lava of 1669 being perforated at Catania, flames issued; and within these eight years it yielded, after rain, smoke and great heat. This lava is about two hundred feet in depth, and two miles in breadth, and had run about fifteen miles. Other basaltic columns appear near Bronte, on the west of Etna, which gave a title to the glorious Nelson. They are in beautiful hexagonal groups, which disappear in the incumbent chalk or earthy limestone. Some not only project from one centre, but are bent as if to cover a convex surface. On the east of Etna, the rock of the Cyclops, here also engraved, presents on its east side beautiful columns of *primeval* lava, disposed in the form of an organ, like the Organ Rock near the giants' causey. Near the castle of Aci, the ancient Acis, are found masses of lava in balls, with concentric layers, eight or ten inches in diameter, involved in a bed of bluish volcanic glass. The superincumbent limestone has infiltrated and crystallised in the little cavities of the glass. A reddish baked clay also appears, and little prisms of lava about two inches in length. In the neighbourhood volcanic balls are also found in tufa, with fragments of lava, glass, drosses, and sand. They are generally about six inches in diameter, and often break into regular pyramids, which are joined in the centre as in balls of pyrites; which, he might have added, marks the same influence of iron*.

No modern lava prismatic. Our learned author totally denies, even in opposition to his friend Spallanzani, that the modern lavas on the east of Etna assume the prismatic form when they reach the sea; and regards this opinion as a mere illusion arising from the fissures common in amorphous lavas, and which may be equally observed in those that are inland. "I must therefore repeat," says he, "that the prismatic lavas around Etna, do not belong to the modern eruptions of that volcano, but to the ancient volcanoes under the ocean; and that modern lavas, whether on the land or in the sea, and under whatever circumstances, never pass into regular forms; but only appear in shapeless masses, or in such accidental shapes as arise from their site or refrigeration. Two or three prisms which I have found of modern lava near Mount Finocchio, on the upland skirts of Etna, and some small ones in the clefts beneath, must, from their singularity, be ascribed to an accident, which can never establish a general system: and I am of opinion that to the same accident may be ascribed the two or four prisms, which some naturalists have found in other modern lavas; and the great difference ought to be remembered between these scarce trifles, and the vast masses of prisms, groups of columns, and fascicular assemblages, of which even the fragments tend to regular divisions, which constitute their characteristic quality."[*]

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* P. 95, 116, 123, 135, 137.

Even the amorphous lava of the primeval period is very compact, sprinkled with filiform crystals of felspar, and some of siderite, with grains of chrysolite. That of Cape Passaro takes a beautiful polish. "The prismatic lavas are very hard and compact, and always of a dull ashy colour, or a bluish black; and I have never observed any pores in prismatic lava."[†] Among these primeval products is also found black or blue obsidian, sometimes in fragments, sometimes in tables in the slits of the lava, and sometimes concave, as enveloping balls of lava. Fragments are also found partly glass and partly lava, the former appearing in delicate veins. While the lava is decomposed into black ferruginous earth, the obsidian passes into a light ashy substance. The bubbles and cavities are full of calcareous spar, while others, though rarely, present confused crystals of white and semitransparent quartz*.

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[*] P. 144. He had before said, p. 112, "In generale posso dire che le lave prismatiche, le lave basaltine, i basalti, che sono intorno alla base dell' Etna appartengono agli ANTICHI VOLCANI, e non mai alle eruzione moderne di questo volcano."

[†] P. 176.

In fine, our laborious and intelligent author concludes that "those Neptunists, who deny the volcanic origin of the basaltic columns of Sicily, must never have observed them, else they might have seen them surrounded with amorphous lava of the same identic paste, and often continuous with them; and must have seen in the mass fissures which indicate regular divisions."† Such is this important work of Ferrara, which must be pronounced one of the most solid and judicious that has yet appeared upon the subject.

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* P. 177, 179, &c.

† P. 316.

If the observations on this curious topic, which has so long occupied scientific men, should in this and other parts of the work sometimes appear contradictory, let it be regarded as a proof of the author's candour, and not of his inattention to a subject far from being ascertained.

The account of the volcanic substances will extend to considerable length, and some degree of prolixity may be found in the minuteness of the details, which was necessary for the sake of accuracy; especially as these substances have been *objects* of repeated disputes and contestations among the mineralogists and geologists.

NOME I. COMPACT LAVA.

The volcanic substances are of such various kinds, that their arrangement becomes more difficult. By far the most important substance is the lava, which must be considered chiefly as it is compact or porous, the former requiring particular attention. In Karsten's catalogue there are only two bits of lava; and as Buffon had prejudices against certain rocks which contradicted his system, so Werner seems absolutely to shut his eyes upon the grandeur and importance of volcanic productions. Hence they are treated with great neglect, and may be said to be excluded from German cabinets; while, to the impartial observer, they convey sublime ideas of the wonderful power of nature.

Basaltin.

As the opinion that basaltin is at least sometimes volcanic, appears to gain ground, it must, when identified by its geognosy, be admitted as the most compact of all lavas. Like porous lava, it very often contains grains, or even nodules, of olivine, or what has been called chrysolite; and zeolite forms likewise a common parasitic substance. Neither of these, it would appear, is found in siderite, or in the basalt of the ancients; whose most common admixtures are quartz and felspar, and in some porphyries chalcedony. This observation, if exact, would seem of itself to indicate a different origin; for if basaltin were merely the more earthy and compact appearance of the siderous substances, hornblende, and grunstein, as asserted by the Wernerians, it seems difficult to imagine why its parasites should thus totally differ. Chrysolite or olivine also occurs in the masses of native iron, and other stones said to have fallen from the atmosphere; and which are well known to appear in the form of fiery meteors, and to bear other palpable marks of fusion by heat*.

Arrangement. In this division, the terms HYPONOME and MICRONOME, implying greater and smaller subdivisions of the Nome, will become still more necessary, and more strictly applicable, as, though the subjects resemble each other, they are widely different in a geological point of view. The want of such denominations has obliged the writers on volcanic products to divide them into new and unusual classes, genera, and species; in violation of the other provinces of mineralogy, where these terms bear quite a different interpretation. Hence the genera of Dolomieu are, 1. Compact lava. 2. Porous lava. 3. Scoriæ, &c. &c.; while the genera of Werner are Flint, Clay, Lime, &c. Here, on the contrary, basaltin remains a mode among the siderous substances, being only a different combination; while among the volcanic it becomes a hyponome, being amidst the accidential, not the elemental, rocks; not in a series of similar combinations, but in a mere assemblage of substances of quite distinct natures, but all altered by fire.

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* Perhaps in a heated state the magnesia may combine with the silex, and the potash evaporate; so that felspar and magnesia may become olivine.

HYPONOME I. VOLCANIC BASALTIN.

Volcanic basaltin from Etna, Vesuvius, the isle of Bourbon, &c.

The same, with olivine, from the isle of Bourbon.

The same, with zeolite, from Etna.

Micronome 1. The same, with various substances involved in the volcanic torrent.

Micronome 2. The same, with fragments of ejected rock.

Micronome 3. Compact lava, with melted garnets, from Vesuvius. The appearance is rather vitreous.

HYPONOME II. POROUS BASALTIN.

The three very compact homogenous lavas of Dolomieu are probably original rocks; for he speaks of their occurrence in blocks*; and the grand error of his volcanic treatises is, that he confounds antecedent rocks and ejections with lavas.

The siderous compact lavas are thus described by Brochant; who has, however, in this part of his valuable work, followed the arrangement and ideas of Dolomieu.

Brochant's account.

"These lavas are commonly of a black colour, more or less deep, seldom grey or brown: their fracture is imperfectly conchoidal, their contexture very compact; they are harder, but more brittle than trap, rather sonorous, very heavy; they melt, under the blow-pipe, into black scoriæ; they attract the magnet; they give, by breathing on them, an earthy smell: this lava is one of the most common in volcanic regions, above all in the currents which have issued from Etna, and which are almost entirely composed of it.

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* Etna, 185.

"It is seldom that they are homogenous; they are, on the contrary, almost always interspersed with different minerals; those which have been most remarked are felspar, augite, hornblende, garnet, leucite, olivine, and mica."*

Recently Breislak, certainly an intelligent writer, mentions many kinds of compact lava, without any notice concerning their rarity or singularity†. Ferber, an unprejudiced judge, likewise gives a catalogue of compact lavas, amounting to fifteen kinds. He especially says that the common black lava, which covers Vesuvius on every side, is porous on the surface, spongy, and light, and therefore employed in vaulted roofs; but at a greater depth it is extremely compact, and then used in foundations, and in paving the streets‡. Yet he compares it with slags; and speaks of its being mixed with a reddish iron ochre, like the rocks under the basaltin in the north of Ireland, and in the Faroe isles. But Ferber possibly means only porous lava, which he styles compact, in comparison with the common vesicular lava: and it is possible that the latter may abound in cabinets, because it is easily detached from the

Ferber's ideas.

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* Brochant, ii. 626.

† Voyage dans la Campanie, Paris, 1801, 8vo.

‡ Letters on Italy, p. 154.

surface; while considerable labour and time must be employed to arrive at the true compact lava*.

It must also be remembered that Ferber regards basaltin as a volcanic production, in which he is followed by almost every writer, German or French, who has visited volcanic countries. As it is Werner's plan never to decide on substances or regions, which he has not seen with his own eyes, it is much to be regretted that he did not visit Vesuvius, if he could not attain the majestic scenes of Etna.

While the French writers are often so prejudiced in favour of volcanoes, that with them every black or vesicular stone is a lava; and the Germans, on the other hand, deny even obsidian and pumice to be volcanic; both sides injuring their own cause by pushing it to an absurd excess; it may be satisfactory to know the ideas of Ferber, who is at least regarded as an unprejudiced writer. Besides the black homogenous lava, above mentioned, his other compact sorts are black with leucites, with felspar, with siderite, with chrysolite, with vesuvian, with obsidian. He adds four kinds of grey compact lava, with siderite, augite, felspar; and red compact lava with leucite and felspar. But by his immediate transition to the *lapilli*, the sand, and the powders, he would rather seem by the term *compact*, to imply a vague distinction from the *loose* substances, than a strict application of the word: and this, among a thousand instances, may show the necessity of austere language, and the most precise definitions in mineralogy.

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* Saussure, i. 128, 4to. has observed, that compact lava is very rare, and found only in the interior of the current. So also Ferrara, p. 301, "la parte bassa dei torrenti è formata di lava piu o meno compatta."

Opinion of Faujas.

Faujas used to indicate five differences between trap and compact lava. 1. Trap is soft, and may be scratched by a knife, which on lava loses edge. 2. Trap attracts iron, but lava is a magnet. 3. In electricity, lava acts like glass. 4. There is no olivine in trap, but it is common in lava. 5. Trap in a furnace becomes a transparent glass, but lava remains opake. These distinctions will not, however, be admitted by the Neptunists. In Brongniart's opinion, compact lava always presents a grain somewhat crystallised, in which it differs from trap*. If basaltic columns be found on Etna, their origin may still remain dubious; for, according to Gioeni, the radical parts of that mountain are basalt, which is only concealed by the lavas*. But Ferrara seems to have decided this inquiry.

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* i. 551.

Porous basaltin, with olivine, from Etna.

The same, with leucite, from Vesuvius.

The same, with augite, the pyroxene of *Haüy*; which contains about 15 of iron, and seems a mere modification of siderite.

Micronome 1. Grey compact lava.

All lavas, as already mentioned, with a few trifling exceptions of mere curiosity, may be classed in two divisions: those with a base of siderite, and those with a base of felsite. The grey lavas often belong to the latter division; but are sometimes so intermingled with siderite, that they appear delicately dotted or punctuated. Vesuvius presents lava of this kind, which, in spite of the interspersion of mica, receives an admirable polish.

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* P. 52. Chrysolite, or olivine, is common in native iron, and in lava, ib. 217. Gallitzin (Rec. des Noms, Brunsw. 1801, 4to.) mentions an iron ore articulated like basalt, *mine de fer en prismes articulés, comme le basalte.* Brochant has a red hematite of iron in prisms, from the Fichtelberg near Bareuth.

The pretended basaltin of Wales, observed by Strange and others, at Cader Idris, is, according to recent and more accurate observers, a coarse grunstein or basalton, in rude oblong fragments occasioned by fissures. Appearances more volcanic may be traced in the north of Ireland; where the red earth resembles puzzolana; the *krag* of Kirwan, found near Belfast, is very *porous;* and the *mullen* seems to some an ash-grey lava with hornblende. Deluc, Geol. 273, expresses his belief in the extinct volcanoes of Germany, and says that sections of lava may be observed turned to a central point, and forming circles of hills around an empty space, the focus having sunk and disappeared. He calls these volcanic crowns; and the centre is often a lake.

Faujas, in his general classification of volcanic products, has denominated this kind *Laves feldspathiques;* and mentions one which is black, yet melts under the blow-pipe into a white amel. Some, on the contrary, belong to the white compact lavas, about to be described*.

Grey lavas of Faujas.

The grey sorts are, " Felsite lava, of a clear grey, sometimes bluish, sometimes rather greenish, or white a little inclined to red, of a fine paste, rather disposed in little plates than in grains, with mica more or less black, and a multitude of irregular grains of a felspar, whiter or a little yellowish, which infringes on the base, and whose parts have a contexture and a direction different from that of the base of the lava.

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* In his ideas, trap resembles felsite; but he forgets that iron, always a most predominant and characteristic substance, is wanting in felsite.

His classification of volcanic substances was first published in the *Annales du Museum*; and latterly, with great variations, in his *Geologie*, tome ii. The extracts here given are generally from the former, which is more ample and instructive, on some topics, than his last revision.

" Felsite lava of a grey white, fine paste, scaly, and of a shining reflection, and satiny, of an analogous nature to the preceding in respect to its composition; but differs in as much as the action of volcanic fire has impressed on the paste a character of fusion similar to that of pumice, while the granular fragments of felspar, whiter and of a more diaphanous nature, which are immersed in the massive felspar, have more resisted the action of fire, and remain nearly untouched.

" Felsite lava of a deep Isabella colour, with grains of white diaphanous felspar, and a number of small specks of black mica, which have remained untouched in the midst of the striated base, rather porous, and passed into the state of pumice. This felsite lava has relations with the preceding; but its contexture is more rough, and its pores closer; its aspect has an appearance of pitchstone; which obtained it, from Dolomieu, the name of *resiniform lava*.

" Grey felsite lava, with a multitude of small globules more or less round, and inherent in the base, of a substance analogous to that of felspar, of a deeper colour than the paste which contains them, and in which they have been primitively formed: their contexture is closer and rather vitreous. This lava, which is hard, and susceptible of being polished, appears spotted, and presents very small lineaments of black mica; scratches glass, and melts under the blow-pipe into a greyish white amel.

"Felsite lava, grey, and sometimes of a whitish grey, analogous to the foregoing, with the difference that, in this, the paste, which also encloses some lineaments of black mica, is looser and less adherent, and that the spherical globules are much larger, and of a felspar a little vitreous, but very compact. They cannot be better compared than to large peas. Some specimens are found, where the base which contains them being in part destroyed, the globules have resisted, and offer saliant protuberances which have a false appearance of orbicular crystals. These contain in their interior, as well as on their surface, linear portions of felspar, whiter than the globular paste which contains them; there are also some specks of black mica. It is probable that these globules may pass into a kind of obsidian called *luchs saphir*, when a violent heat produces vitrification."

As the base of this lava consists of felspar or felsite, it is often very compact. In describing an immense current, which descends from the ancient crater of Etna towards Mascali, Dolomieu says that it lies under vesicular lava, and is of a very fine grain, and conchoidal fracture, like petrosilex, that is felsite*. There are some white spots of undissolved felspar, and some specks of siderite, which occasionally appear rusty and earthy from the oxygenation of the iron. He also describes a grey homogenous lava, of a very fine grain, with very small dots of a clearer colour, which, examined with a lens, present a looser texture than the other parts, and have often pores in their centre. His *laves silicées* also belong to this kind, being as compact as porcelain, with spangles of black mica, while sometimes there are long fibres, as in melted glass†.

Breislak says that the grey lava, which issued from Vesuvius in the noted eruption of 1794, is in some parts so compact that the grain resembles flint. It has a faint interspersion of mica‡.

Grey compact lava, with very small pores, abounds at Volvic in Auvergne, where it is used in building: it chiefly reposes on a fine grained grey granite.

Micronome 2. White compact lava.

This kind is uncommon, and must arise from pure melted felsite. Dolomieu specially observes that the tint is original, and not derived from sulphurous vapours*. Even earthy lavas and basalt may be found of a white colour; but this always arises from the action of vapours. White lava is found in the little isle of Ischia†.

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* Dolomieu Etna, 240. See afterwards Breislak's account of the eruption of Vesuvius, 1794.

† Ponces, 104.

‡ i. 222.

Micronome 3. Brown compact lava.

This colour may arise from the iron mingled in red felsite.

HYPONOME III. PORPHYRITIC LAVA.

As both the substances most general in lavas, namely, siderite and felspar, also constitute genuine porphyry, it is naturally to be expected that lava should sometimes assume this structure. The ingenious observer of Etna gives the following account‡.

Dolomieu's account.

"I denominate all those lavas porphyritic, which present crystals of felspar, when those crystals are of a different colour from the base which contains them, and from spots in it.

"This species is most common: it in itself constitutes more than half of the compact lavas of

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* Etna, 161.

† Ponces, p. 71, and 109.

‡ Dolomieu, 212.

Etna; it may even be said that porphyry is the essential base of almost all the lavas of that volcano; that it chiefly characterises the productions of Etna, and distinguishes it from other volcanoes, where in general porphyries are more rare.

"The size, number, and form of the crystals of felspar, and the colour of their base, will distinguish the varieties of this species; but I shall not consider as varieties, the accidents of the fractures, which, according to their direction, offer inequalities in the form and size of the felspar, especially when the crystals are very much flattened, and resemble a piece of money.

"Felspar is not always solitary in these lavas, it is often accompanied with black schorl, and sometimes chrysolites; both these substances are equally found in some antique porphyries.

"The base, or ground of all these porphyritic lavas resembles those simple lavas described in the first species: some, however, are more subject to be inflated, and have a more vitreous grain; besides the felspar is never altered in its form, or organisation, only sometimes it is a little cracked. It is generally observed that the more the lavas have undergone a violent action of fire, the whiter the felspar has become; an effect which may be produced by exposing green porphyry to the fire, or antique serpentine, in which the base becomes black, while the felspar whitens; it then acquires the property of strongly acting on the magnet.

"Most porphyritic lavas are susceptible of a fine polish, which always increases the strength of their colour; they then acquire as much brightness and beauty as natural porphyries, and may be substituted for them; only porphyries of a purple, and green bases, are not found among them, because those two colours become black in a less degree of heat than that of volcanoes."

The most common porphyritic lava of Etna is of a greyish black with white spots, the base resembling basalt. But the work of Dolomieu having been published before mineralogy had acquired great precision, it is to be feared that he has often confounded the lavas with the original rocks.

In one of his porphyritic lavas he observed crystals of specular iron; and as he also observed this metal in the same state in the dross of Monte Rosso, he concludes that it is formed by sublimation*.

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* Etna, 379.

NOME II. VESICULAR LAVA.

This is the most general and undoubted product of volcanic fires. The vesicles are sometimes of an oblong form, but often spherical, especially in those with a base of siderite, which, even in vitrification, does not assume the fibrous form common to other substances.

Analysis.

From the lava which contains leucite, Vauquelin derived silex 53, argil 18, lime 2, oxyd of iron 6, potash about 17. The leucite itself contained very little iron, but presented the same ingredients as the lava, with 20 of potash.

Vesicular lava is the most common and characteristic production of volcanoes, among which Etna has been chiefly celebrated for more than two thousand years. The torrents of liquid fire, vaguely mentioned through a long series of learned and illiterate ages, consisted of inflamed vesicular lava. Many were the attempts to explore the source of this phenomenon, the summit of a mountain so interesting to curiosity and even to science. But the best account is that of Spallanzani, at once a natural philosopher and a mineralogist, and who has sprinkled his description with some learned anecdotes of the his-

Summit of Etna.

tory of this celebrated mountain. Its length and minuteness will only render it the more acceptable to the intelligent reader, especially as they may serve to diversify the dry brevity of some parts of this domain. It may also be considered as a counterpart to the description of the summit of Mont Blanc, by Saussure, which is given in a former division of this work.

"Three hours before day I, with my companions, left the *Grotta delle Capre*, which had afforded us a welcome asylum; though our bed was not of the softest, as it consisted only of a few oak leaves scattered over the floor of lava. I continued my journey towards the summit of Etna; and the clearness of the sky induced me to hope that it would continue the same during the approaching day, that I might enjoy the extensive and sublime prospect from the top of this lofty mountain, which is usually involved in clouds. I soon left the middle region and entered the upper one, which is entirely destitute of vegetation, except a few bushes very thinly scattered. The light of several torches, which were carried before us, enabled me to observe the nature of the ground over which we passed, and to ascertain, from such experiments as I was able to make, that our road lay over lavas either perfectly the same with, or analogous to, those in which the *Grotta delle Capre* is hollowed.

"We had arrived at within about four miles of the borders of the great crater, when the dawn of day began to disperse the darkness of night. Faint gleams of a whitish light were succeeded by the ruddy hues of Aurora; and soon after the sun rose above the horizon, turbid at first and dimmed by mists, but his rays insensibly became more clear and resplendent. These gradations of the rising day are no where to be viewed with such precision and delight as from the lofty height we had reached, which was not far from the most elevated point of Etna. Here likewise I began to perceive the effects of the eruption of Etna, which took place in July 1787, and which has been so accurately described by the Chevalier Gioeni*. These were visible in a coating of black scoriæ, at first thin, but which became gradually thicker as I approached the summit of the mountain, till it composed a stratum of several palms in thickness. Over these scoriæ I was obliged to proceed, not without considerable difficulty and fatigue, as my leg at

Drosses.

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* "His account of this eruption was printed at Catania, in 1787. There is likewise a French translation at the end of the *Catalogue Raisonné* of M. Dolomieu." An English translation of this singular account is afterwards here given.

every step sank deep into it. The figure of these scoriæ, the smallest of which are about a line, or somewhat less, in diameter, is very irregular. Externally they have the appearance of scoriæ of iron; and when broken, are found full of small cavities, which are almost all spherical, or nearly of that figure. They are therefore light and friable, two qualities which are almost always inseparable from scoriæ. This great number of cavities is an evident proof of the quantity and vigorous action of the elastic fluids, which in this eruption, imprisoned in the liquid matter within the crater, dilated it on every side, seeking to extricate themselves; and forced it, in scoriaceous particles, to various heights and distances, according to the respective weights of those particles. The most attentive eye cannot discover in them the smallest shorl; either because these stones have been perfectly fused, and with the lava passed into homogenous consistence, or because they never existed in it. Some linear felspars are however found, which by their splendour, semitransparency, and solidity, show that they have suffered no injury from the fire. When these scoriæ are pulverized, they become extremely black; but retain the dryness and scabrous contexture which they had when entire. They abound in iron, and in consequence the dust produced by pulverising them, copiously adheres to the point of the magnetised knife; and a small piece of these scoriæ will put the magnetic needle in motion at the distance of two lines.

Balls of lava. "In the midst of this immense quantity of scoriæ, I in several places met with some substances of a spherical figure, which, like the lava, were at first small, but increased in size as I approached the summit of the mountain. These were originally particles of lava ejected from the crater in the eruption before mentioned, which assumed a spherical figure when they were congealed by the coldness of the air. On examining them, I found them in their qualities perfectly to resemble the scoriæ, and to possess the same magnetism.

Smoke. "Only two miles and a half remained of our journey, when the great laboratory of nature, enclosed within the abysses of Etna, began its astonishing operations. Two white columns of smoke arose from its summit: one, which was the smallest, towards the north-east side of the mountain; and the other towards the north-west. A light wind blowing from the east, they both made a curve towards the west, gradually dilating, until they disappeared in the wide expanse of air. Several streams of smoke, which arose lower down towards the west, followed the two columns. These appearances could not but tend to inspire me with new ardour to prosecute my journey, that I might discover and admire the secrets of this stupendous volcano. The sun likewise shining in all his splendour, seemed to promise that this day should crown my wishes. But experience taught me that the two miles and a half I had yet to go, presented many more obstacles than I could have imagined; and that nothing but the resolution I had formed to complete my design at every hazard, could have enabled me to surmount them.

Lava of 1787.

"Having proceeded about a hundred paces further, I met with a torrent of lava, which I was obliged to cross to arrive at the smoking summit. My guides informed me that this lava had issued from the mountain in October 1787; and as the account of the Chevalier Gioeni, which I have cited, only mentions the eruption of the month of July of the same year, I shall here give a brief description of it, as it does not seem hitherto to have been described.

"This very recent lava extends three miles in length; its breadth is various, in some places being about a quarter of a mile, in others one-third, and in others still more. Its height, or rather depth, is different in different parts; the greatest being, as far as I was able to observe, about eighteen feet, and the least six. Its course is down the west side of the mountain; and, like the other lava which flowed in July 1787, it issued immediately from the great crater of Etna. The whole number of the eruptions of this mountain of which we have any record, before and after the Christian æra, is thirty-one; and ten only, as we are informed by Gioeni, including that of which he has given an account, have issued immediately from the highest crater. That which I observed may be the eleventh, unless it should rather be considered as the same with that described by the Sicilian naturalist, since the interval between August and October is a very short intermission of rest for a volcano. The cause of the rarity of the eruptions which issue immediately from the crater, compared with those which disgorge from the sides, seems easily to be assigned. The centre of this volcano is probably at a great depth, and perhaps on a level with the sea. It is therefore much more easy for the matter liquified by the fire, put in effervescence by the elastic fluids, and impelled on every side from the centre to the circumference, to force its way through one of the sides of the mountain where it finds least resistance, and there form a current; than to be

uptions from the crater.

thrown up, notwithstanding the resistance of gravity, from the bottom to so great a height as the highest crater of Etna. It is evident, therefore, that the effervescence in the eruptions of the months of July and October 1787, was extremely violent. The torrent of the month of October is every where covered with scoriæ, which resemble those ejected in the month of July in their black colour, but differ from them in the great adhesion they have to the lava, in their exterior vitreous appearance, their greater weight, and their hardness, which is so great that they give sparks with steel almost as plentifully as flints. These differences, however, are to be attributed only to accidental combinations of the same substance; the constituent principles of the scoriæ of this lava not being different from those of the detached scoriæ mentioned above. Both likewise contain the same felspar lamellæ.

Difficul
asce

"This new current was however very difficult, and even dangerous, in the passage. In some places the scoriæ projected in prominent angles and points, and in others sunk in hollows, or steep declivities; in some, from their fragility and smoothness, they resembled thin plates of ice, and in others they presented vertical and sharp projections. In addition to these difficulties, my guides informed me I should have to pass three places where the lava was still red-hot, though it was now eleven months since it had ceased to flow. These obstacles, however, could not overcome my resolution to surmount them, and I then experienced, as I have frequently done at other times, how much may be effected in difficulties and dangers like these, by mere physical courage, by the assistance of which we may proceed along the edge of a precipice in safety; while the adventurer who suffers himself to be surprised by a panic fear, will be induced cowardly to desist from the enterprize he might have completed. In several places, it is true, the scoriæ broke under my feet; and in others I slipped, and had nearly fallen into cavities from which I should have been with difficulty extricated. One of the three places pointed out by the guides had likewise, from its extreme heat, proved highly disagreeable; yet at length I surmounted all these obstacles and reached the opposite side, not without making several cursory observations on the places whence these heats originated. Two large clefts, or apertures, in different places appeared in the lava, which there, notwithstanding the clearness of the day, had an obscure redness; and on applying the end of the staff which

I had used as a support in this difficult journey, to one of these, it presently smoked, and immediately after took fire. It was therefore indubitable that this heap of ejected lava still contained within it the active remains of fire, which were more manifest there than in other places, because those matters were there collected in greater quantities.

Cone of Etna.

"I had yet to encounter other obstacles. I had to pass that tract which may properly be called the cone of Etna, and which, in a right line, is about a mile or somewhat more in length. This was extremely steep, and not less rugged, from the accumulated scoriæ which had been heaped upon it in the last eruption, the pieces of which were neither connected together, nor attached to the ground; so that frequently when I stepped upon one of them, before I could advance my other foot, it gave way, and forcing other pieces before it down the steep declivity, carried me with it, compelling me to take many steps backwards instead of one forwards. To add to this inconvenience, the larger pieces of scoriæ above that on which I had stepped, being deprived of the support of those contiguous to them, came rolling down upon me, not without danger of violently bruising my feet, or breaking my legs. After several ineffectual attempts to proceed, I found the only method to avoid this inconvenience and continue my journey, was to step only on those large pieces of scoriæ which, on account of their weight, remained firm; but the length of the way was thus more than *doubled*, by the circuitous windings it was necessary to make to find such pieces of scoriæ as, from their large size, were capable of affording a stable support. I employed three hours in passing, or rather dragging myself, to the top of the mountain, partly from being unable to proceed in a right line, and partly from the steepness of the declivity, which obliged me to climb with my hands and feet, sweating and breathless, and under the necessity of stopping at intervals to rest, and recover my strength. How much did I then envy the good fortune of those who had visited Etna before the irruption of 1787, when, as my guides assured me, the journey was far less difficult and laborious!

"I was not more than a hundred and *fifty* paces distant from the vertex of the cone, and already beheld close to me, in all their majesty, the two columns of smoke. Anxious to reach the borders of the stupendous gulf, I summoned the little strength I had remaining to make a last effort, when an unforeseen obstacle for a moment cruelly retarded the completion of my ardent wishes. The volcanic craters, which are still burning more or less, are usually surrounded with hot sulphureous acid steams, which issue from their sides and rise in the air. From these the summit of Etna is not exempt; but the largest of them rose to the west, and I was on the south-east side. Here likewise four or five streams of smoke arose from a part somewhat lower, and through these it was necessary to pass; since on one side was a dreadful precipice, and on the other so steep a declivity, that I and my companion, from weakness and fatigue, were unable to ascend it; and it was with the utmost difficulty that our two guides made their way up it, notwithstanding they were so much accustomed to such laborious expeditions. We continued our journey, therefore, through the midst of the vapours; but, though we ran as fast as the ground and our strength would permit, the sulphureous steams with which they were loaded were extremely offensive and prejudicial to respiration, and affected me in particular so much, that for some moments I was deprived of sense; and found, by experience, how dangerous an undertaking it is to visit volcanic regions infested by such vapours.

"Having passed this place, and recovered by degrees my former presence of mind, in less than Crate an hour I arrived at the utmost summit of Etna, and began to discover the edges of the crater; when our guides, who had preceded me at some distance, turned back, and hastening towards me, exclaimed, in a kind of transport, that I never could have arrived at a more proper time to discover and observe the internal part of this stupendous volcano. The reader will easily conceive, without my attempting to describe it, how great a pleasure I felt at finding my labours and fatigue at length crowned with such complete success. This pleasure was exalted to a kind of rapture when I had completely reached the spot, and perceived that I might without danger contemplate this amazing spectacle. I sat down near the edge of the crater, and remained there two hours, to recover my strength after the fatigues I had undergone in my journey. I viewed with astonishment the configuration of the borders, the internal sides, the form of its immense cavern, its bottom, an aperture which appeared in it, the melted matter which boiled within, and the smoke which ascended from it. The whole of this stupendous scene was distinctly displayed before me; and I shall now proceed to give some description of it, though it will only be possible to present the reader with a very feeble image, as the sight alone can enable him to form ideas at all adequate to objects so grand and astonishing.

"The upper edges of the crater, to judge by the eye, are about a mile and a half in circuit, and form an oval, the longest diameter of which extends from east to west. As they are in several places broken, and crumbled away in large fragments, they appear as it were indented, and these indentations are a kind of enormous steps, formed of projecting lavas and scoriæ. The internal sides of the cavern, or crater, are inclined in different angles in different places. To the west their declivity is slight; they are more steep to the north; still more so to the east; and to the south-east, on which side I was, they are almost perpendicular. Notwithstanding this irregularity, however, they form a kind of funnel, large at the top and narrow at the bottom, as we usually observe in other craters. The sides appear irregularly rugged, and abound with concretions of an orange colour, which at first I took for sulphur, but afterwards found to be the muriate of ammoniac, having been able to gather some pieces of it from the edges of the gulf. The bottom is nearly a horizontal plane, about two-thirds of a mile in circumference. It appears striped with yellow, probably from the above mentioned salt. In this plane, from the place where I stood, a circular aperture was visible, apparently about five poles in diameter, from which issued the larger column of smoke, which I had seen before I arrived at the summit of Etna. I shall not mention several streams of smoke, which arose like thin clouds from the same bottom, and different places in the sides. The principal column, which at its origin might be about twenty feet in diameter, ascended rapidly in a perpendicular direction while it was within the crater; but when it had risen above the edges, inclined towards the west, from the action of a light wind, and, when it had risen higher, dilated into an extended but thin volume. This smoke was white, and being impelled to the side opposite to that in which I was, did not prevent my seeing within the aperture; in which I can affirm I very distinctly perceived a liquid ignited matter, which continually undulated, boiled, and rose and fell, without spreading over the bottom. This certainly was the melted lava, which had arisen to that aperture from the bottom of the Etnean gulf.

"The favourable circumstance of having this aperture immediately under my view, induced me to throw into it some large stones, by rolling them down the steep declivity below me. These stones, which were only large pieces of lava that

I had detached from the edges of the crater, bounding down the side, in a few moments fell on the bottom, and those which entered into the aperture, and struck the liquid lava, produced a sound similar to that they would have occasioned had they fallen into a thick tenacious paste. Every stone I thus threw, struck against and loosened others in its passage, which fell with it, and in like manner struck and detached others in their way, whence the sounds produced were considerably multiplied. The stones which fell on the bottom rebounded, even when they were very large, and returned a sound different from that I have before described. The bottom cannot therefore be considered only a thin crust; since, were it not thick and solid, it must have been broken by stones so heavy falling from so great a height.

"To satisfy one emotion of curiosity, is frequently to excite another. I had at first approached this volcano with a kind of superstitious awe. The histories of every age, the relations of travellers, the universal voice of Europe, had all contributed to inspire those who should adventure to visit it with dread: but as at this time it seemed to have laid aside its terrors, and was in a state of perfect calmness and tranquillity, I was encouraged to become more familiar, and to endeavour to pry into more of its secrets. I have already observed that the side of the crater to the west is of a more gentle declivity than the others; and I therefore conceived that this might serve me as a ladder to descend to the bottom, where I might have added to the observations I had already made, other new and important facts. But the persons whom I had brought with me as guides, would not consent that I should expose myself to such danger. They could not, however, prevent me from making at my ease the observations I have here published, and walking leisurely about the summit of the mountain, notwithstanding the dangerous consequences with which they threatened me: telling me that, should the wind change, the column of smoke must be turned towards us, and might deprive us of life by its pestilential fumes; that besides, we were not certain that the lava at the bottom, which now appeared so calm and still, would long remain in the same state; but that it was possible, from circumstances difficult to foresee, that it might be thrown up on a sudden, and punish our imprudent curiosity by burying us beneath the fiery ruin; in support of which suggestion they produced several instances of sudden and most unexpected eruptions.

"We have seen above that there were two columns of smoke arising from Etna. It is to be remarked that, besides that point of Mount Etna on which I stood, there is another to the north, a quarter of a mile higher, and which renders the summit of Etna properly bifurcated. Within the first prominence is sunk the crater I have described; and on the side of the other is the second, from which ascends a lesser column of smoke. The second crater is smaller by about the one-half than that I have already described; and the one is separated from the other only by a partition of scoriæ and accumulated lava, which lies in the direction of from east to west. I made my observations on this second crater from a small distance; but it was impossible to advance to it, on account of the numerous and thick streams of smoke by which it was surrounded. This, however, was no great disappointment, after having seen and examined the principal crater, which is that whence several currents of lava had issued in 1787. I ought certainly to consider myself as extremely fortunate, in being able to gratify my curiosity with so near and distinct a view of the objects I have described; as the guides assured me that among all the times when they had conducted strangers to the summit of Etna, this was the only one in

Second

which they had a clear and undisturbed view of the internal parts of that immense gulf. After my return to Catania, the Chevalier Gioeni likewise declared to me that in his different excursions to that mountain he had never had a good fortune similar to mine; and that a month before my arrival he had made a journey to Etna with the Chevalier Dangios, furnished with the necessary instruments to ascertain accurately the height of the mountain; but when they had arrived at the foot of the cone, where they had proposed to begin their operations, they were obliged to return back, from the obstacles they met with, which, to say the truth, are commonly neither few nor small.

"Etna rises to a prodigious height above the level of the sea, and its summit is usually covered with snows and ice, and obscured with clouds, except when the latter are low, and range along the sides. The winds likewise frequently blow with such violence, that persons can scarcely keep their feet, not to mention the acute cold which benumbs the limbs. But the most formidable impediments to the progress of the adventurers who attempt this perilous journey, are the streams of sulphureous vapour which rise on the sides, and the thick clouds of sulphureous smoke which burst forth from the mouth of the volcano, even when not in a state of agitation. It seems as if nature had placed these noxious fumes as a guard to Etna, and other fiery mountains, to prevent the approach of curiosity, and secure her mysterious and wondrous labours from discovery. I should, however, justly incur the reproach of being ungrateful, were I not to acknowledge the generous partiality she appeared to manifest towards me. At the time I made my visit the sky was clear, the mountain free from snows, the temperature of the atmosphere not incommodious, the thermometer standing at seven degrees above the freezing point (48° of Fahrenheit), and the wind favouring my design, by driving the smoke of the crater from me, which otherwise would alone have been sufficient to have frustrated all my attempts. The streams of smoke I met with in my way were indeed somewhat troublesome, but they might have been much more so; though, had our guides conducted us by another road, as on my return to Catania I found they might have done, we should have escaped this inconvenience.

Other accounts.

" It here will not be improper to compare these observations on the crater of Etna with those of Baron Riedesel, Sir William Hamilton, Mr. Brydone, and Count Borch; as such a comparison will show the great changes which have taken place in this volcano within the space of twenty years; that is, from the time when it was visited by Baron Riedesel in 1767, to that of my journey in 1788. At the time when that traveller made his observations, the crater was enlarged towards the east, with an aperture which now no longer exists. He has not given the measure of its circuit, nor has he mentioned the interior aspect of the crater; probably because he had not seen it, having been, as I imagine, prevented by the quantity of smoke which he tells us continually ascended from it.

Riedesel.

"It is worthy of notice, however, that at that time there was not at the bottom of the crater the hard flat surface I have described; since the stones thrown into it did not return the smallest sound. Within the gulf itself was heard a noise similar to that of the waves of the sea when agitated by a tempest, which noise probably proceeded from the lava within the bowels of the mountain, liquefied and in motion. We may hence conceive how easily a volcano may begin to rage on a sudden, though before apparently in a state of complete tranquillity; for if we suppose a superabundant quantity of elastic substances to have been suddenly developed in the liquid lava of Etna, either at the time when Baron Riedesel visited the crater, or when I observed it in a state of slight commotion within the gulf, it must immediately have swelled in every part, beating violently against the sides of the caverns in which it was imprisoned, thundered among the deep cavities, and, bursting forth through the sides, have poured out a river of fire; or should its violence have been there resisted, it would have rushed up within the crater, until it overflowed its brink, and deluged the sides of the mountain with its torrents.

Hamilton.

" Sir William Hamilton, on the 26th of October, 1769, arrived at the summit of Etna with great difficulty, on account of the snows he met with in his way, the severity of the atmosphere, the sulphureous vapours, and the violence of the wind. He was unable to view distinctly the lower parts of the crater, being prevented by the great quantity of smoke which issued from it; though when this smoke was sometimes driven away by the wind, he could discover that the crater was shaped like a funnel, diminishing until it ended in a point; and that this funnel was incrusted over with salt and sulphur. The crater was two miles and a half in circumference.

" From the time therefore of the journey of Baron Riedesel to that of Sir William Hamilton, the crater must have undergone great changes in its structure; since if the stones that were thrown into it gave no indications to the ear that they struck against any solid body, it is manifest that there must then have been an abyss as well as a funnel; and as the funnel terminated in a point when it was observed by Sir William Hamilton, it is evident that the flat bottom I have described, and which was about two thirds of a mile in circuit, did not then exist.

"The internal sides of the crater, Sir William tells us, were covered with a crust of salt and sulphur; but he does not specify the nature of the former; and though the presence of the latter is not improbable, he might have been led into a mistake by the yellow colour, and have taken the muriate of ammoniac (sal ammoniac) for sulphur, as I did before I examined it. Sir William has not told us that he made any examination at all; and it is probable that he judged only from the appearance it presented to his eye.

"He observes, lastly, that the crater was two miles and a half in circumference; an estimate which may be made to agree with mine by neglecting the partition which separates the greater crater from the less, and considering them both as one. The sum of the two circumferences, according to the estimate I have given, would then greatly differ from the measure of Sir William Hamilton. Nothing likewise can be more probable, than that among the various changes that have happened to Etna, this partition, by which the great crater is divided into two parts, has been produced.

"Omitting the observations of Mr. Brydone, that "the tremendous gulf of Etna, so celebrated in all ages, has been looked upon as the terror both of this and another life; that it inspires such awe and horror, that it is not surprising that it has been considered as the place of the damned;" and other similar philosophical reflections which he has employed; and confining ourselves to what he actually saw on the 29th of May, 1770, we learn from him that "the crater was then a circle of about three miles and a half in circumference; that it went shelving down on each side, and formed a regular hollow, like a vast amphitheatre; and that a great mouth opened near the centre*.

"From the time of the journey of Sir William Hamilton therefore, to that of the visit of Brydone, that is to say, within the short space of a year, various changes had happened to this volcano, by the enlargement of its crater, and a spacious aperture formed in its bottom.

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* Brydone's Tour through Sicily and Malta, vol. i. 195, 196.

Borch.

"Count Borch appears to have wished to exceed the three other travellers in brevity, relative to this subject; since he only tells us that he arrived at the mountain on the 16th of December, 1776, and that the crater of Etna is formed like a funnel. He adds, however, what is worthy of notice, that the summit of Etna is bifurcated, as I observed it to be; a circumstance not noticed by others, Sir William Hamilton even affirming that the summit of the mountain is single; whence we may conclude that one of these summits has been produced since the time of the journey of Brydone, in 1770.

"On comparing the above-cited observations, made within the space of twenty-one years, we may perceive how many changes have taken place in Etna during that interval; and as within that time the mountain has suffered only two violent convulsions, in the eruptions of 1781 and 1787, it is evident that even in the state of apparent inaction, it still internally exerts its force.

D'Orville.

"To these observations it may likewise not be without utility to add those of M. D'Orville.

He ascended Etna in 1727, and remarked two craters, one larger than the other. The latter he only mentions, but the former he describes at some length. Its circumference was perhaps somewhat more than four miles. From it issued clouds of smoke and reddish flames. These, however, did not prevent his approaching to the edge of the gulf; though, to prevent the danger of falling into it, he and his companions fastened themselves to a rope held by three men. On looking into the crater, they were unable to discern the bottom, on account of the flames and smoke: they only observed that a conical hill, formed of lava, rose in the middle of the crater, the top of which they estimated to be sixty feet below them; and they were able to see perhaps about sixty lower; where, as they conjectured, the circuit of this hill might be from six hundred to eight hundred feet*.

"We have here a remarkable circumstance relative to Etna, as it appeared in the time of M. D'Orville, and not observed by any one of the four travellers above cited, I mean the conical hill within the crater. Every observation, therefore, tends to confirm the inconstancy of the internal configuration and dimensions of this volcano. It is an unextinguished forge, which in proportion to the violence of the fire, to the nature of the fossil matter on which it acts, and of the elastic fluids which urge and set it in motion, produces, destroys, and re-produces various forms. The usual and natural figure of the summit of a volcanic mountain, is that of an inverted concave cone within, and one solid and erect without; and such a configuration, in countries which are no longer in a state of conflagration, is one of the most certain indications of the existence of an ancient volcano. This cone, however, is liable to very great changes; according to the greater or less fury of the volcano, and the quantity and quality of the matters ejected. Its internal part, from more than one cause, is exposed to continual violence and change. The prodigious cavities of the mountain make it almost appear suspended in the air. It may easily therefore give way, and fall in; especially on the violent impulse of new matters, which endeavour to force a passage through the upper part; in consequence of which the inverted cone may, according to circumstances, present the appearance of an aperture, or whirlpool, or a gulf. Should the liquid lava pass through the aperture, and continue there some time, its superficies by the contact of the cold air losing its heat gradually, would congeal and form a crust or solid plane; and should the fluid lava beneath, afterwards act forcibly on this crust, it might burst it, or make a passage where it found least resistance; in which case the melted lava would occupy that aperture. Should then the crust, instead of ascending in a single body, be forced up in small fragments, these cooled in the air, would fall down in immense quantities within the crater; and, from the effect of the laws of gravity, must accumulate in the figure of a cone. These theoretical conjectures, if they do not perfectly explain, may at least enable us to conceive the nature of the causes, which have produced the difference of appearance observed at different times in the crater of Etna.

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* Jacobi Philippi D'Orville Sicula.

Changes.

"It is much to be regretted that we have no history of Etna; which, did we possess it, must greatly contribute to elucidate the theory of volcanoes, and the causes of the various changes which have taken place at different times, in the summit of this mountain. That such changes have happened, is evident from the few but valuable notices concerning Etna, which we find in ancient authors. Of these I shall briefly state two or three, which appear to be of most importance.

Strabo, &c.

"I shall first produce the authority of Strabo, though he was not himself an ocular witness, but relied on the information of others, who had visited Etna, and from whom he received the account, 'That the summit was a level plain of about twenty stadia in circumference, surrounded by a brow or ridge, of the height of a wall; and that in the middle of the plain arose a smoky hill, the smoke of which ascended in a direct line, to the height of two hundred feet.' If we consider this description as accurate, the crater of Etna was at that time surrounded by a brow or ridge, which I should explain as the sides or edges; and in the lower part, was separated by a mount rising in the middle*. The same geographer relates, that two men having ventured to descend upon the plain, were obliged immediately to return, from the violence of the heat.

"Solinus tells us that there were two craters from which the vapours issued†.

Bembo.

"Cardinal Bembo likewise found two craters on the summit, the one higher than the other, and about as far distant as a stone might be thrown from a sling. The extreme violence of the wind, and the exhaling fumes, prevented him from approaching the upper crater. The lower he found to be formed like an immense pit, and surrounded with a plain of no great extent, which was so hot that he could not bear his hand on it. From its mouth, as from a chimney, continually issued a column of smoke.

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* "This observation agrees with that of D'Orville, mentioned above. I find likewise that similar mounts have sometimes been thrown up within the crater of Vesuvius. See *De Bottis Istoria di varii incendii del Vesuvio.*"

† "In Etnæ vertice hiatus duo sunt, crateres nominati, per quos eructatus erumpit vapor. Cap. xi.

"Of the other crater, which he could not observe himself, he received a description, at Catania, from a monk, who, he assures us, was a man deserving credit, and well acquainted with such subjects. He informed him that this crater was situated on the highest part of the summit of Etna; that it was about three miles in circumference; formed like a funnel; and that it had in the middle a spacious cavity. He asserted that he had made the circuit of it, along a kind of narrow ridge; that from time to time, it threw out stones and burning matters to a considerable height, roaring, and shaking the ground; but that in the intervals, when it was undisturbed, he had observed it without danger or difficulty.

Fazello.

"In the time of Fazello, however, who visited Etna after Cardinal Bembo, there were no longer two craters, but only one; the circumference of which, as he informs us, was four miles. It had the usual form of the funnel, emitted fire and thick smoke; but at intervals was calm, and might be approached; at which times a subterraneous noise was heard, and a sound like that of the boiling of an immense caldron on a vast fire. These observations were made by him in 1541, and 1544; in both which years the crater appears to have been single*.

"These few citations appear to me sufficient to show what changes have taken place in the summit of Etna, relative to the number, the form, and the size of its craters, according to the different effects of its conflagrations at different times. But there is likewise another alteration which should not be passed unnoticed, described by two writers who themselves observed it, Fazello and Borelli; I mean the falling in and absorption of the extreme summit of Etna within its crater. The former of the above mentioned authors relates that in his time there arose, in the mouth of the crater, a little hill, isolated on every side, which formed the vertex of the mountain; and which, in a terrible eruption, fell into and was buried in the gulf, thus enlarging the crater, and diminishing the height of the mountain. This hill itself had been produced by a former eruption in 1444[*].

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* Fazel. Sic.

"In like manner, Borelli informs us that in the conflagration of 1669, the summit of Etna, which rose like a tower to a great height above the part which is level, was swallowed up in the deep gulf[†].

"I have already said, that when I visited Etna, its summit was divided into two points, or little mountains, one of which rose a quarter of a mile above the other. I should not be surprised were I to hear that in some new and fierce eruption, the highest of these had fallen in, and the two craters became one of much larger dimensions. We know that the summit of Vesuvius has sometimes fallen down in the same manner; nor does it appear difficult to assign the cause. It seems to admit of no doubt that the highest parts of Etna, and other mountains which vomit fire from their summits, have their foundations on the sides of the crater, which extend to an immense depth. In any violent earthquake therefore, or impetuous shock of the lava endeavouring to force a passage, it may easily be imagined that those foundations must be torn up and broken away, and the summit of the volcano fall and be lost in the gulf.

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[*] Ubi sup. Borelli Hist. Inc. Ætnæ, 1669, 4to.

[†] Ubi sup.

"These dilapidations have not, however, from time immemorial, produced any sensible diminution of the height of the summit of *Etna*; since the losses occasioned by some eruptions are repaired by others which follow. This may be inferred from a phenomenon usually inseparable from the summit of Etna, though, by rare accident, not observable at the time of my journey; I mean the ice and snow with which it is covered. Had any considerable decrease of the height of the mountain taken place, in consequence of the summit repeatedly falling in, in former ages, the ice and snow would not certainly, in a climate so mild, have continued to envelop the top of the mountain as they now do, even during the heats of summer. But this continual residence of the snow and ice on Etna has been celebrated by all antiquity; for near observation was not necessary to ascertain *this* phenomenon, since it is distinctly apparent at the distance of a hundred miles. *Adscendit ea regio* (says Fazello, speaking of the upper region of Etna) *passuum millia fere xii; quæ per hyemem tota nivibus obsita extremisque frigoribus riget: per æstatem quoque nulla sui parte nec canitie nec gelu caret: quod equidem admiratione dignum*

Ice and snow.

est; cum vertex incendia prope sempiterna jugi flammarum eructatione inter nives ipsas pariat, enutriat, ac continuet. 'This region extends nearly twelve miles; and, even in summer, is almost perpetually covered with snow, and extremely cold; which is the more wonderful as the summit continually produces, nourishes, and pours forth flames amid the ice and snow with which it is enveloped.'

Ancient accounts.

"Solinus and Silius Italicus give the same description. The former says, *Mirum est quod in illa ferventis naturæ pervicacia mixtas ignibus (Ætna) nives profert: et licet vastis exundet incendiis, aprica canitie perpetuo brumalem detinet faciem*[*]. 'Etna, in a wonderful manner, exhibits snows mixed with fires; and retains every appearance of the severest winter amid her vast conflagrations.'

"Silius Italicus has the following lines:

'Summo cana jugo cohibet (mirabile dictu)
Vicinam flammis glaciem, æternoque rigore
Ardentes horrent scopuli; stat vertice celsi
Collis hyems, calidaque nivem tegit atra favilla[†].'

'Where burning Etna, towering, threats the skies,
'Mid flames and ice the lofty rocks arise;
The fire amid eternal winter glows,
And the warm ashes hide the hoary snows.'

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[*] Cap. xi.

[†] Lib. xiv.

And since I have quoted a poet, I will cite two others; Claudian and Pindar; as it is sufficiently evident that poetry here must express truth, and not fiction.

'Sed quamvis nimio fervens exuberet æstu,
Scit nivibus servare fidem: pariterque favillis
Durescit glacies, tanti secura vaporis,
Arcano defensa gelu, fumoque fideli
Lambit contiguas innoxia flamma pruinas*.'

'Amid the fires accumulates the snow,
And frost remains where burning ashes glow;
O'er ice eternal sweep th' inactive flames,
And winter, spite of fire, the region claims.'

"Thus the Latin poet; but the Greek has given us a picture of Etna much more highly coloured, representing it not only as the eternal abode of snows, but as the column of heaven, to express its astonishing height.

Κιων δ᾽ ουρανια συνεχει
Νιφοεσσ᾽ Αιτνα πανετες
Χιονος ὀξειας τιθηνα†.

——————'Snowy Etna, nurse of endless frost,
The mighty prop of heaven.'

It is to be remarked that Pindar lived five hundred years before the Christian æra.

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* Claud. de Rapt. Pros.

† Pind. Pyth. Od. i.

Smoke.

"I now return from this digression, which, though not indeed very short, appears to me perfectly appropriate to the subject; and proceed to resume my narrative. I shall first speak briefly of a phenomenon relative to the smoke which arises from the crater of Etna, and which was seen differently by Mr. Brydone, Count Borch, and myself. Mr. Brydone tells us that "from many places of the crater issue volumes of sulphureous smoke, which being much heavier than the circumambient air, instead of rising in it, as smoke generally does, immediately on its getting out of the crater, rolls down the side of the mountain like a torrent, till coming to that part of the atmosphere of the same specific gravity with itself, it shoots off horizontally, and forms a large track in the air, according to the direction of the wind."

"On the contrary, the smoke when seen by Count Borch, at the intervals when the air was calm, arose, perpendicularly, to a great height, and afterwards fell, like white fleeces, on the top of the mountain. I shall not presume to doubt these two facts, though I observed neither of them. The two columns of smoke which I saw, though bent somewhat from the perpendicular by the wind, ascended with the usual promptitude of ordinary smoke (a certain proof that it was considerably lighter than the ambient air), and, when at a certain height, became extremely rarefied and dispersed. This difference in the appearance of the smoke, as observed by the two authors before mentioned and myself, may arise not only from the gravity of the air on Etna being different at different times, but also from the diversity of the smoke, which may be sometimes lighter and sometimes heavier than the air that surrounds it; differing in its nature according to the quality of the substances from which it is produced. Such a variation in its specific gravity, must induce us to conclude that the bodies which burn within the crater are specifically different.

Air. " The effects of the air at the summit of Etna, as experienced by myself and some of the travellers I have before cited, were likewise different. Sir William Hamilton tells us, that the thinness of that fluid occasioned a difficulty of respiration; and Count Borch appears to have experienced a still greater inconvenience of that kind, since he says, " The rarity of the air on this mountain is extremely sensible, and almost renders that fluid unfit for respiration." On the contrary, Baron Riedesel felt no such effect, as far at least as we can judge from his own words. "I did not perceive, as several travellers have asserted, that the air here is so thin and rarefied as to prevent, or at least greatly incommode, respiration." Mr. Brydone has said nothing on the subject, and his silence may induce us to conclude that he experienced no difficulty.

"I, my servant, and the two guides, suffered no inconvenience from the air. The exertions we had made, indeed, in climbing up the craggy steep declivities which surround the crater, produced a shortness of breathing; but when we had reached the summit, and recovered from our weariness by rest, we felt no kind of inconvenience, either while sitting, or when, incited by curiosity, we went round and examined different parts of the edges of the crater. The same is affirmed by Borelli: *Æque bene respiratio in cacumine Ætnæ absolvitur, ac in locis subjectis campestribus.*—'Respiration is performed with the same ease on the top of Etna, as in the country below.'

"Several writers have treated of the difficulty of respiration experienced by those who travel over high mountains, and other inconveniences to which they are exposed; but none, in my opinion, more judiciously than M. Saussure, in his travels among the Alps. The observations he has made, appear to me to explain the cause of these different accounts, relative to the effect of the air on the top of Etna. When the height above the level of the sea was *two thousand* four hundred and fifty poles, or nearly *such*, which he found to be that of Mont Blanc, every individual felt more or less inconvenience from the rarefaction of the air, as happened to himself and nineteen persons who accompanied him, when in August 1787 he ascended that mountain. But when the elevation was much *less*, as for example, nineteen hundred poles, some of these persons felt no difficulty, among whom was this naturalist; though he confesses that he began to experience inconvenience as he ascended higher. We have not indeed any certain observations relative to the exact height of Etna, as is sufficiently proved by the different estimates given by different naturalists. Signor Dangios, however, astronomer at Malta, in the year 1787, measured the height of this mountain by a geometrical method, and the public anxiously expects the results, which will satisfactorily solve this important problem. In the mean time, from comparing the measures hitherto assigned, the elevation of Etna above the level of the sea is probably somewhat less than nineteen hundred poles*. Hence we understand why respiration, in many persons, is not incommoded, while the contrary happens to others, according to the different strength and habit of body of different individuals.

View from Etna.

"After having, for two hours, indulged my eyes with a view of the interior of the crater, that is, in the contemplation of a spectacle which in its kind, and in the present age, is without a parallel in the world; I turned them to another scene, which is likewise unequalled for the multiplicity, the beauty, and the variety of the objects it presents. In fact, there is, perhaps, no elevated region on the whole globe which offers, at one view, so ample an extent of sea and land as the summit of Etna. The first of the sublime objects which it presents, is the immense mass of its own colossal body. When in the country below it, near Catania, we raise our eyes to this sovereign of the mountains, we certainly survey it with admiration, as it rises majestically, and lifts its lofty head above the clouds; and with a kind of geometric glance we estimate its height from the base to the summit;

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* The height of Etna is generally estimated at 11,000 feet above the sea. Ferrara seems to estimate it at little more than 9000; 1610 *tese* (p. 141). Does he mean the French *toise*?—P.

but we only see it in profile. Very different is the appearance it presents, viewed from its towering top, when the whole of its enormous bulk is subjected to the eye. The first part, and the nearest the observer, is the upper region, which, from the quantity of snows and ice beneath which it is buried during the greater part of the year, may be called the frigid zone, but which at that time was divested of this covering, and only exhibited rough and craggy cliffs, here piled on each other, and there separate, and rising perpendicularly; fearful to view, and impossible to ascend. Towards the middle of this zone, an assemblage of fugitive clouds, irradiated by the sun, and all in motion, increased the wild variety of the scene. Lower down, appeared the middle region, which, from the mildness of its climate, may merit the name of the temperate zone. Its numerous woods, interrupted in various places, seem, like a torn garment, to discover the nudity of the mountain. Here arise a multitude of other mountains, which in any other situation would appear of a gigantic size, but are but pigmies compared to Etna. These have all originated from fiery eruptions. Lastly, the eye contemplates with admiration the lower region, which, from its violent heat, may claim the appellation of the torrid zone; the most extensive of the three, adorned with elegant villas and castles, verdant hills, and flowery fields, and terminated by the extensive coast; where, to the south, stands the beautiful city of Catania, to which the waves of the neighbouring sea serve as a mirror.

" But not only do we discover, from this astonishing elevation, the entire massy body of Mount Etna; but the whole of the island of Sicily, with all its noble cities, lofty hills, extensive plains, and meandering rivers. In the indistinct distance we perceive Malta; but have a clear view of the environs of Messina, and the greater part of Calabria; while Lipari, the fuming Vulcano, the blazing Stromboli, and the other Eolian isles, appear immediately under our feet, and seem as if, on stooping down, we might touch them with the finger.

" Another object, no less superb and majestic, was the far-stretching surface of the subjacent sea which surrounded me, and led my eye to an immense distance, till it seemed gradually to mingle with the heavens.

" Seated in the midst of this theatre of the wonders of nature, I felt an indescribable pleasure from the multiplicity and beauty of the objects I surveyed; and a kind of internal satisfaction and exultation of heart. The sun was advancing to the meridian, unobscured by the smallest cloud, and Réaumur's thermometer stood in the tenth degree above the freezing point. I was therefore in that *temperature* which is most friendly to man; and the *refined* air I breathed, as if it had been entirely vital, communicated a vigour and agility to my limbs, and an activity and life to my ideas, which appeared to be of a celestial nature."

Caverns. The currents of lava sometimes contain caverns of a very considerable extent. In Iceland they afford recesses for the flocks of sheep*. Dolomieu has described a very remarkable one in an island near Sicily; and he also found some in the proximity of Etna, sometimes 30 feet in height and 20 in breadth, the walls and vault being as regular as if they were works of art†. They are numerous; and some, as he asserts, many leagues in length. His explanation is, that the surface of the lava forming a crust, is sometimes arrested by impediments, while the under current continues to flow; so that upon its complete elapse, the space remains void. Thus bridges, of some miles of breadth or length, are found on the Missouri, in North America:

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* Von Troil Voy. d'Islande, Paris, 1781, the best edition revised by the author.

† Lipari.—Etna, 291.

the floating trees being stopped by some obstacle. Similar caverns in Iceland, especially near Hecla, are described by Von Troil.

The vesicular lava, like the compact, may be divided into two principal kinds: those with a base of siderite, and those with a base of felsite.

HYPONOME I. OF SIDERITE.

This is the most common of all the lavas, and covers the sides and skirts of every volcano*. The colour is black or grey, derived from the melted siderite. The vesicles are generally round; the larger, of two or three lines in diameter, being interspersed with many smaller pores. It is often spotted with white spangles of felspar; and the vesicles sometimes contain crystals of the same substance, and sometimes of zeolite. Those of Vesuvius, once itself an extinct volcano, and of the extinct volcanoes of Italy in a more northern direction, often contain leucite, a white stone crystallised like a garnet. This last may be said to form the base of some lavas, comparatively more abundant in cabinets than in nature†.

Homogenous vesicular lava, from Etna, Vesuvius, the Isle of Bourbon, the Puy-de-Dome, &c.

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* Saussure, § 178, concludes that his *roche de corne* forms the base of all the black lavas.

† Dol. Etna, 441, says that pyrites are formed in decomposed lava, in the humid way, by the union of the iron with the sulphur.

The same, with spangles of felspar.

Vesicular lava of a violet colour, from the extinct volcanoes of Provence: see Saussure, § 1485, 1495.

The other kinds are sufficiently remarkable to form regular subdivisions.

Micronome 1. With Leucite.

Lava, with unimpaired leucite, from Vesuvius.

The same, from Albano near Rome.

The same, with decomposed leucite, from the same places*.

Micronome 2. With Zeolite.

Black vesicular lava, with fibrous zeolite.

According to Dolomieu, this is sometimes columnar.

"A porous black lava, the pores being exactly round, and one or two lines in diameter; distant from each other more than six lines, and sometimes one or two inches; the interior of the spherical cavities being blue, while they commonly contain zeolite and calcareous spar. This lava is crystallised in prismatic columns, more or less regular, in the mountains of Trezza and of the castle of Jaci."† Is not this an original rock?

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* See Volcanic Intrites.

† Etna, 303. Jaci is the Aci of Ferrara.

Micronome 3. With Olivine, or Volcanic Chrysolite.

These lavas are remarkable, as the same substance is found in basalt, and in the native iron of Siberia and South America.

HYPONOME II. VESICULAR LAVA WITH A BASE OF FELSITE.

In this kind the vesicles are generally elongated, and it sometimes passes into a fibrous appearance, which, when predominant, is a characteristic of pumice.

Grey or white vesicular lava, from various volcanoes.

Micronome 1. Felsite lava, with crystals of siderite.

Micronome 2. The same, with mica.

NOME III. INDURATED MUD.

American volcanoes.

The American volcanoes chiefly devolve torrents of mud, which seems to be strongly impregnated with iron. Torrents of this kind have also been said to occur in the eruptions of Etna, and even of Vesuvius. Yet no writer has mentioned with precision what form this mud assumes after desiccation. Brochant indeed, who has borrowed his arrangement of the volcanic rocks from Dolomieu, supposes that they become volcanic tufo*. But this substance is generally understood to be formed of volcanic sand and powders, dross, pumice, and pulverised lava. The grand volcanoes of Cotopacsi, Tungarunga, and Sangay, in South America, eject prodigious quantities of mud; and, what is still more striking, vast numbers of fish, so as sometimes to infect the air with putrefaction. These fish appear to be little injured, and are the same with those found in the rivulets at the bottom of the volcanoes, being a *pimelodes silurus*, from two to four inches in length; but they are very rare in the rivulets which they probably remount, in order to pass to subterranean lakes, and are caught by the natives at the very sources; facts which tend to confirm the theory of volcanoes above hinted.

Late writers specially mention that the muddy eruptions become fertile clay, and are very productive; while tufo can never be regarded as a productive soil. If the muddy eruptions be strongly impregnated with iron, they might, on Patrin's theory, become basaltin; or, if mingled with felspar, a clay porphyry. But this curious subject must remain for future investigation[*].

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* This is the Italian and classical orthography. *Tufa* may be reserved for depositions merely aqueous.

Often melted snow.

It was supposed that Etna, during the eruption of 1755, had poured out a torrent of mud; but Ferrara has shown that it was only snow and ice, melted by the lava; and he gives a singular instance of the lava having attacked a mass of ice, which it partially melted, and left only a pile in the midst, which stood for some time like a superb palace of crystal. Ulloa also mentions a torrent of melted snow, which issued from the volcano of Cargaraso in South America[†]. The *water* volcano, as it is called, of Guatimala probably ejects mud; and Ferrara regards Macaluba as belonging to that system of volcanic heat which influences Sicily and the neighbouring isles*.

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[*] Mr. Jameson, (Geogn. 353, Notes,) says the mud of the American volcanoes is called *Koth* by the Spaniards, and *Muya* by the Indians. For this, and some other parts of his Note, he has adduced no authority; and they seem borrowed, as usual, from some inaccurate German writer. He adds, that this mud is of a blackish brown colour, earthy, and not very coherent. There are traces of glassy felspar; but none of sulphur or pyrites. Some kinds are used as fuel, and emit a strong heat, without flame. Klaproth's analysis, by this account, yielded chiefly silex and argil, with carbonic acid, hydrogen gas, amonia, coal, lime, oxyd of iron, and natron. I cannot find it in Klaproth's works.

[†] Ferrara, 165. Ulloa, i. 267, falsely quoted by Ordinaire as a volcano of mud.

His account of the remarkable eruption of this muddy volcano in 1777 is subjoined, as presenting new and singular circumstances.

Eruption of Macaluba.

"Sometimes this phenomenon appears with immense force. The inhabitants of the neighbourhood still remember with terror the eruption of 1777, one of the most violent yet known. On the 29th of September were first heard dreadful bellowings all around, while the earth shook to the distance of some miles; and from the midst of the plain, in which was formed a vast gulf, arose, to the height of about one hundred feet, an immense column of mud; which, at the top, and abandoned by the impulsive force, assumed the form of a large tree. The middle was formed of stones of all kinds and sizes, which darted violently and vertically within the body of the column. This terrible explosion lasted half an hour, when it became quiet; but, after a few minutes, resumed its force, and with these intermittences continued all the day, but the smoke lasted all the night. During the time of this phenomenon, a pungent odour of sulphurated hydrogen gas was felt at a great distance, to the surprise of the inhabitants, who did not dare to approach this spot on account of the horrible noises. But many came the following day, and found that the new great orifice had ejected several streams of liquid chalk *(creta)*, which had covered with an ashy crust of many feet all the surrounding space, filling the cavities and chinks. The hard substances ejected were fragments of calcareous tufo, of crystallised gypsum, pebbles of quartz, and iron pyrites, which had lost their lustre, and were broken in pieces: all *these* substances form the outward circuit at this day. The unpleasant smell of sulphur still continued; and the water, which remained in the holes, continued hot for many months; while a keen smell of burning issued from the numerous orifices around the great gulf, which was now completely filled."*

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* P. 43.

In all events, as indurated mud forms, after lava and tufo, the most abundant ejection of volcanoes, it ought to occupy an important station among their products. It may be divided into two Hyponomes: 1. Entire; 2. Mingled with various substances.

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* Ferr. 45. The name Macaluba is Arabic, signifying the place of *spilling* or *overturning*. This phenomenon is mentioned by Solinus; nay Plato, in his Phœdo, mentions the torrent or spring of mud in Sicily.

NOME IV. TUFO.

Composition.

This may be regarded as the fourth and last of the great volcanic ejections. It is chiefly composed of volcanic sand and powders, or what are absurdly called ashes, of pulverised lava, dross, and pumice. When it consists of ferruginous clay it is properly called *puzzolana;* when of pumice in a recent state, *rapillo* or *lapillo.* For as earths are no longer distinguished from stones, the difference of cohesion not altering the nature of the substance, so tufo* may be regarded as of various *indurations.* These remarks, however, naturally lead to two grand divisions; the HARD tufo, which is used as stone; and the SOFT, or incoherent tufo, which is also called puzzolana, tarras, &c.

Tufo of Iceland.

Troil has observed, that the greater part of the Icelandic mountains consist of tufo; and Hecla often ejects brown and black pumice, with sand and powder, of which substances it chiefly consists, interspersed with fragments of slate, either originally red or changed by fire. Perhaps the base of the mountain may consist of slate; and the red puzzolana of the Italians may be merely that substance affected by fire.

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* Italian writers always put *tufo.* It might be a not unuseful distinction, as already stated, to confine *tufa* to the calcareous and other depositions merely aquatic.

Volcanic powders.

It is well known that, during the grand eruptions of volcanoes, the sun is often hid, for entire days, with thick columns and clouds of comminuted substances, called *ashes* by modern writers; while the ancients, with their usual discernment, used the word *powder**. On their fall, these powders become coherent and indurated, by humidity and the lapse of ages, so as often to assume the consistence of stone. These are also among the most dangerous phenomena; the city Pompeia having been overwhelmed with a hail of pumice, while Herculaneum was buried under a shower of powders; and in the theatre, constructed without a roof as usual among the ancients, a piece was found impressed with the breasts of a woman, who had perished; a circumstance which evinces the tenuity of the substance. The hills of the isle of Ponza often present a white argillaceous tufo, extremely soft, being chiefly composed of comminuted pumice†. Breislak observed in Ischia, hills of a fine white tufo, sometimes stratified;

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* *Involutus est dies pulvere, populosque subita nox terruit.* Seneca Quest. nat. l. 2. &c. &c.

† Dolomieu, Ponces, 118.

and it sometimes assumes the appearance of pisolite.

A chief part of volcanoes.

Dolomieu has asserted, that tufo forms nine tenths of Mount Etna, and its filial hills; but Ferrara, a more competent observer, *will* not allow that one-half is of this substance. *The* recent eruptions of this grand and perpetual volcano have, however, been chiefly remarkable for those ejections of drosses, powders, and sand, which form tufo, as the reader will observe from the following accounts of Gioeni and Ferrara, yet untranslated; and who, being skilful mineralogists, deserve more confidence than common travellers and narrators. Some degree of prolixity is indispensable, as already *observed, in* scientific details; and in the description of such grand and wonderful phenomena, minuteness, as in historical anecdotes, increases the pleasure of the perusal.

Remarkable in late eruptions.

Gioeni's account of the eruption of Etna, in July 1787, is introduced by the following remarks of Dolomieu, and letter of the French Consul at Messina.

Dolomieu's account.

"While on the point of closing the enumeration and description of the productions of Etna, this volcano, which, during six years, had remained inactive and quiet, experienced new convulsions: they began about the 15th of June, and were the forerunners of an eruption, which manifested the greatest activity about the middle of July: the eruption was remarkable on account of the immense quantity of ashes, sand, and light pulverulent scoriæ, which issued from its crater*. They covered the mountain, were expanded over a part of Sicily, and carried even as far as Malta. The Chevalier Dangios collected, on the terraces of the observatory at that place, a pretty large quantity of black sand, in small hard grains, which were attracted by the magnet: the sand was mingled with small and somewhat transparent crystals, of irregular figure, which, seen through the microscope, appeared to be a porous vitrification; this sand was borne to Malta by a north-west wind, on the night between the 18th and 19th of July.

"Many currents of lava were emitted by this eruption, and consequently all those kinds of substances which I have attributed to this crisis. I have received different accounts of this event, which may be serviceable in developing the theory of subterranean fires, and support certain observations I have given in this catalogue. I cannot therefore terminate this work more properly, in my opinion, than with an extract from a letter of M. L'Allement, French Consul at Messina, in which some curious details will be found; and a translation, by myself, of the narrative of the Chevalier Don Joseph Gioeni, published in Italian, at Catania, in September 1787.

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* "These numerous products of scorification announce very considerable effervescence, and are constantly attended with a great disengagement of elastic fluids. Hence the column of smoke and flame rose to an immense height; and the atmosphere was infected with the odour of sulphur."

"*Extract of the Letter of* M. L'ALLEMENT, *French Consul at Messina, addressed to the Commander Dolomieu*[*].

Letter of the consul.

"Precisely six years and two months had elapsed since the last external symptom of fermentation exhibited by Etna, when, towards the close of the month of June, the cloud of smoke with which its summit is commonly crowned, was observed to increase in size; this smoke occasionally assumed the complexion of fire.

"Early in July, an opening was remarked on the edge of the crater in the north-west, and the fire, as seen from Catania, exactly resembled the full-moon at its rising above the horizon: the lava made a slow progress for two days; it occupied a space on the slope of two miles; became, on cooling, grey and shining; and for a time all ceased.

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[*] He was a Knight-commander of the Order of Malta.

"In the night between the 9th and 10th, an aurora borealis was distinguished, which was visible for the space of half an hour, and was repeated; it was largely spread and covered the whole horizon from Monte Rosso as far as Noto: its colour was that of light, but somewhat deeper, and its direction being the same as that of the eruption which it preceded, many conceived it to be connected with it, and even foretold that it would happen.

"In effect, on the 13th, a black and thick smoke was again seen on the summit, which progressively increased, and fire was shot forth more frequently and in greater abundance; but, in the morning of the 16th, though the glare of the sun and the thickness of the smoke prevented part of the active fire, which issued from the mouth of the volcano, from being seen, the extreme heat of the atmosphere, the noise from the mountain, and the subterranean explosions which shook the whole of its base, announced the violence of the eruption being at its acme; still this was not the case until the next day, and at ten at night it presented a most terrible, but, at the same time, a most interesting spectacle: a column of fire, of astonishing volume, was seen to rise from the mouth, the height of which was estimated at about five hundred toises; at the same time a strong lateral current of lava was discovered running in a south-west direction, and which leaving the base of the column, formed a right angle with it, the lines nearly equal in length.

"The column itself presented in the colours it displayed the greatest variety: the inflamed part, abounding in a prodigious quantity of water and sand, was occasionally mingled with a chiar' oscuro, which at every instant threatened the flame with extinction, but which ultimately tended only to increase its vivacity (and on these occasions was it that the eruption was distinctly visible at Messina), and the dark and caliginous part above, throughout its whole extent, was illuminated by flashes of fire, electrical aigrettes, and evulsions of ignited stones; so that what with the explosions of the crater, and the incessant subterranean rumbling, a strong similitude was afforded to the ear of a distant tempest.

"This spectacle was presented during two successive days; on the 19th, all seemed appeased. It is not with Etna as with Vesuvius; for no one presumes to approach this mountain when in a state of fermentation, and only after several days of tranquillity dares even the observer venture on his researches.

"All that can at present be said is, that the great current of lava which flowed from one of the sides of the crater, ran the space of four leagues, alternately threatening the towns of *Randazzo* and *Bronte*, especially the latter, which the inhabitants were on the point of abandoning, but we have not heard of its having experienced any material damage; the ignited stones wounded two peasants, who were at work at the ice-houses, at the distance of two leagues from the summit; the rain of sand, which fell in abundance on the plain of *Mascari*, and in the territory of *Jaci*, destroyed almost all the crops.

"The following are the results of the observations of those who, after the termination of the last eruption, visited Etna: 1°. The summit of Etna is inaccessible from the vast quantity of lava, and of black and friable pumice (drosses), with which it is entirely covered, and which yet retain an intolerable heat; 2°. The great crater is closed, and another has been formed of equal dimensions between that and the one on the western side, closed some years before; 3°. The matter of the eruption is of two kinds only, saline and earthy; 4°. By analysis the saline matter is found to consist of sal ammoniac, in white and yellowish crystals, and in a tolerably pure state; and many compounds of sal ammoniac, mingled with very fine volcanic sand, which has prevented this salt from assuming its natural form and colour: the earthy matter is compounded, in various proportions, of earth, clay, iron, and lime."

"*Translation, by Dolomieu, of the Narrative of the Chevalier* DON JOSEPH GIOENI, *Member of various Academies, and an Inhabitant of the first Region of Etna.*

"Interdumque atram prorumpit ad æthera nubem,
Turbine fumantem piceo, et candente favillâ.
VIRG. l. iii. ÆN.

Gioeni's account.

"From the year 1781, the epoch of the last eruption of Etna, that mountain continued perfectly inactive; rarely did smoke ascend from its crater, and even during the earthquakes which destroyed Messina and part of Calabria, the vents of this volcano seemed to be closed.

First appearance.

"About the middle of the last month of June 1787, I inhabited a country-house in the middle region of the mountain, and daily remarked a smoke which, issuing from the crater, fell on the cone, and covered the summit of the volcano; I observed occasionally, during the night, that this smoke towards the centre was of the colour of fire; it gradually augmented to the 24th of June, when, by rising in a vertical column, it foretold a speedy eruption.

"Flames were visible on the evening of the same day, and continued to be so until the night of the 27th.

Thick smoke.

"On the 28th, at eight in the morning, an immense column of smoke was seen issuing from the crater, of white, black, and red colours, which, after attaining a considerable elevation, was unable to sustain its weight, and, as if compressed, assumed the form of a pine; after this, it sent forth a horizontal line, forming an angle of 80 degrees with the column in a vertical position, and taking a direction towards the south-east.

Of drosses and powders.

"This species of thick and opake cloud, formed by the smoke, after traversing a part of Sicily, extended forty miles out to sea; it showered over the whole space it covered a quantity of light scoriæ and ashes; while this was passing, fresh volumes of thick smoke rose from the crater, took at a certain elevation the same direction along the horizon, and furnished the cloud with the volcanic matters it incessantly showered down. This cloud continued thus supplied until the night of the 30th, when it wholly disappeared*.

"In the morning of the 30th, Catania and the neighbourhood were covered with a small layer of extremely fine powders.

"The flames and smoke continued during the night; and the smoke, extending from the summit towards the west, indicated the direction of an eruption of lava; the volcano continued in this state without any remarkable alteration, other than occasional subterranean shocks.

"On the 8th of July, at two in the afternoon, the smoke increased, rising in white and opake globular clouds, which rapidly succeeded each other; by these clouds the mountain was covered, and the atmosphere was loaded with them to an immense height; they spread towards the west, in the direction of the wind: at the same time a roaring was heard under ground, accompanied by concussions of the earth; the repeated peals of thunder were echoed through the air, while the smoke in the west and north-east was furrowed by continual flashes of lightning of various colours; this smoke so much resembled a cloud laden with hail, that every body conceived it to forebode a violent storm; the cloud remained in this state the space of four hours, when it was utterly dissipated by the violence of the wind; the flames continued three days and nights without intermission.

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* "On visiting the spots covered by this rain of powder, I remarked that the smoke had formed a bend towards the south, as, on leaving the crater, it passed over *Trifaglietto* and *Zafurana*, and thence, directing its course by the woods of Jaci, it reached the sea above *Santa Tecla*."

Lightnings.

"On the 12th and 13th, neither flame nor smoke were visible proceeding from the crater; and on the night of the 13th, three quarters of an hour after nine, a weak aurora borealis was distinguished, beginning towards the west, and extending eastward, passing north of Etna; this illumination ceased about eleven o'clock, but re-appeared, in the same position as before, at one in the morning: it then exhibited radii, apparently diverging from a centre behind the mountain, and at intervals shone with more splendour than at others; it continued thus visible the space of an hour.

Aurora borealis.

"On the following days the flames increased, the subterranean roarings were loud, and the concussions so violent as to shake the houses; deeming myself therefore no longer safe so near the summit, I removed to Catania.

Shocks.

"In the night of the 17th, and throughout

Clouds of sand.

the 18th, the subterranean noise was almost uninterrupted; at five in the evening, clouds of white smoke, streaked with black, sprang forth in rapid succession, the one cloud driving forward the other; they covered the mountain and spread over Catania, excluding the light of day during eight hours; the clouds showered down, almost perpetually, a rain of very shining black sand; the atmosphere at first was loaded with vapours of a reddish yellow colour, which were perceptible the space of an hour, and diffused on all sides a smell of sulphur, that continued for several hours.

"While these vapours infected the atmosphere the thermometer of Reaumur rose from *24¼* to 28⅓ (*71*⅓ to 83⅓ of Fahrenheit); which proves that the temperature of the air was increased by the heat of the sand.

"In the course of the first three hours this rain of ashes formed a bed two-thirds of a line in thickness; in the five succeeding hours, the quantity that fell was the third of a line.

Crater.

"The crater, at sun-set, presented a wonderful spectacle, easier for the painter than the writer to describe: the flames rose to a height greater than ever was known before; they were distinctly seen divided into three large columns, which rose either at once, or at separate intervals, and shot forth an abundance of ignited stones; part of which falling back into the crater, seemed to augment the violence of the flame, while the other part rolled to a considerable distance down the flanks of the cone.

" The smoke, accumulated at a considerable height, was mingled with flames, which cast a light on objects similar to a weak moon-light; it occupied a great horizontal extent, above which rose the three columns of fire. Another column of very dense smoke was noticed, proceeding at intervals from a vent in front of the others; it concealed for some instants the centre of explosion, and, extending towards the south, united with the other smoke, which, forming an arch several miles in length, served as a conductor to the electric fires; its extremity was frequently furrowed by lightning.

Column of fire.

" The height of this column of fire, which continued from eleven o'clock till midnight, seen from Catania, was estimated at half that of the mountain.

" After the eruption had lasted five hours, the mountain was enveloped in the deepest darkness, except the crater, which still emitted flames to the same height as the day before; besides the first, three other currents of lava seemed to be ejected; one towards the east, and two towards the south, and all in divergent radii from the crater; but observing them afterwards with a good telescope, I perceived that the three supposed currents of lava were no other than masses of scoriæ heaped together during the eruption, which continued to burn on the flanks of the cone, and which became extinct at four in the morning.

"A second eruption seemed to announce itself on the following day, when, at noon, an immense number of whirling clouds of white smoke issued from the crater, spread themselves from east to west, and by three o'clock attained an immense elevation; it seemed as though they would cover the city of Catania; but they merely terminated in flashes of lightning, similar to those of the day before, rather more pale, and which issued from the more elevated globes. I afterwards understood, that in the second and third region, some aqueous clouds uniting with the smoke, a very violent rain fell mingled with volcanic matters, differing in a small degree from the first; in the space of an hour, the whole was dissipated, and the mountain was clear.

"The ordinary flames continued during the night of the 20th of July; they somewhat increased at two in the morning, and even assumed the form of a column; but the fermentation diminishing, they resumed their former appearance in about half an hour's time, and preserved the same during two or three days, subsequent to which the mountain resumed its pristine tranquillity.

"It is evidently visible that, on this eruption, the extent of the crater was diminished towards the south, and increased towards the west.

"From the testimony of individuals worthy of credit, I learn that, on the 18th of July, blocks of dross, weighing a pound and a half, ejected from the crater, fell in the valley of *Bue*, that is to say, five miles and a third part of a mile from the spot; others likewise were thrown to different distances, in all directions round about the crater, diminishing in size in proportion to the distance. Size of drosses.

"At *La Cava Secca*, six miles from the crater, some fell the size of a pigeon's-egg; at twelve miles from it, fragments of dross blended with sand formed a bed more than three inches in thickness. During the rain of which I have spoken, the whole of the middle region of Etna was enveloped in darkness; but chiefly in the eastern part, where the greatest quantity fell.

"The inhabitants of *Zafarana* were unable to see each other at the distance of two feet; and, when the flames began to appear, they were enveloped in vapours of intolerable heat; they imagined the mountain was sinking into the abyss from which it sprung: part of the inhabitants abandoned the viliage, and consternation was universal; the volcanic matter retained a heat which it communicated to the atmosphere, and the air was loaded with reddish vapour; the rain that fell ruined the vineyards and trees of the middle region, the latter in many parts having nothing but the trunk left standing.

" From *Bronte* we had information that, during the night of the 18th of July, a current of lava from the crater surrounded a wood in the neighbourhood of the town; and from its having made a progress of several miles in very little time, it caused there the greatest alarm.

" Feeling a desire of examining on the spot the effects of this eruption, the more extraordinary from its having proceeded from the summit, and not occasioned any opening in the flanks of the mountain, I repaired in the beginning of August to Bronte: this town, situated northwest of the crater, stands at the distance of six miles from it, in a direct line; within the interval are several volcanic mountains, and currents of lava which have traversed and laid waste a thick wood of fir, whose deep roots were fixed

Bronte.

in ancient lava, decomposed and converted into earth*. After passing those arid spots, I ascended a hill, from which I clearly distinguished two new currents of lava: the first had flowed W. N. W. of the crater over the flanks of the cone, between the two territories of Bronte and Aderno; I was assured that the breadth of this stream was a mile, and its length three miles; it was formed on the 16th and 17th of July, and on the 18th the rate of its progress had so much diminished that it ceased to advance more than a few fathoms. I was unable to approach it, on account of the steepness of the rocks by which it was surrounded. The second stream, which took the direction N. W. by N., was, at its issuing from the crater, half a mile in breadth; it spread afterwards so as to become a mile broad, and descending rather in an oblique line down the rapid slope of this part of the cone, divided into different currents, which left between them

Currents of lava.

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* "I was obliged to traverse the current of lava, made by the eruption of 1766, the most recent of any which took this direction; I saw several streams of lava which had crossed others, and which afforded me evident proofs of the fallacy of the conclusions of those who seek to estimate the period of the formation of the beds of lava from the change they have undergone. Some lavas, of earlier date than others, still resist the weather, and present a vitreous and unaltered surface, while the lavas of later date already begin to be covered with vegetation."

various eminences they met in their course; these streams united to form but two branches, after having flowed over a space of four miles in a very short period of time, in the night of the 18th.

"Nearly the whole surface of this lava was covered with smoke, which issued from crevices in the mass, and which increased in quantity in proportion to its proximity to the crater; much smoke likewise arose from the crater itself. At two in the morning, the thermometer of Reaumur stood at $19\frac{1}{4}$ ($66\frac{11}{20}$ of Fahrenheit*).

"On reaching the extremity of one of the branches of lava recently ejected, I found it still continued hot, and the heat was more sensible as I advanced upon it. The thickness of this stream did not exceed sixteen feet. Placing the thermometer upon the drosses on the surface, the mercury rose to *28* ($82\frac{2}{5}$ of Fahrenheit), and had the guide allowed us to advance farther, the heat would have been still greater†. *I* brought away some of the light drosses and heavy lava, of which the whole of this current seemed to be composed.

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* "Before I reached the lava, I made an experiment with the new atmospherical electrometer of M. de Saussure; the air, notwithstanding I raised my arm with the instrument as high as possible, exhibited no indications of electricity."

† "The divergency of the balls of the electrometer, with which I here made some experiments, did not exceed the fraction of a line;

"Learning for certain that there was not on the north of Etna any new current of lava, I trod back my steps towards *Nicolosi.* I re-ascended the mountain on the 11th of August, and bent my way directly towards the crater, to examine the changes which an explosion so violent must necessarily have effected: smoke rose from the crater in great abundance, and to a considerable height; but, driven by the wind towards the east, it was no prevention to my plan.

"From the very walls of Nicolosi I noticed that the earth was covered with small fragments of light dross, which became larger in proportion as I approached the summit; I found they had covered the whole space denominated the plain *del Lago,* in such manner that the former soil could no longer be distinguished; the time of my departure on the excursion was half past nine in the morning, and the thermometer stood *$11\frac{1}{3}$* (*$52\frac{1}{4}$* of Fahrenheit).

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and it disappeared at three feet distance from the lava. To ascertain correctly whether or not there really was any difference in the state of electricity, I several times got upon and descended from the lava, and found not the slightest divergency of the balls on removing to a distance of forty paces; the slight electricity in the lava was of a positive kind, as I convinced myself by means of a stick of Spanish wax."

"On reaching the Philosopher's Tower*, my guide measured the height of the bed of drosses, and found it three feet; but, at the foot of the cone, two miles distant from the crater in a right line, I computed the stratum of drosses to be twelve feet in thickness.

"I found a number of insulated round blocks, which had been thrown out from the volcano towards the W. S. W., and in the same direction I saw a current of lava, still inflamed and smoking, which was descending from the crater, and at its origin was about half a *mile* in breadth; it afterwards swelled to a breadth of three miles, and extended two miles in length; the height of the current, at its sides, was from twelve to sixteen feet, but in the middle twice or even four times as much; the current continued to receive fresh matter from the crater, as was indicated by the slow motion of the drosses with which its surface was covered, and the flames which proceeded from the occasionally cloven surface, and which, notwithstanding the day-light, were visible; we at the same time perceived that the progress, in a forward direction of the current, was arrested.

Another current.

"The portion of the cone we had to pass, in

Cone.

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* Probably built when the Emperor Hadrian twice visited Etna.—P.

order to reach the crater, being covered with this lava, we were consequently obliged to advance over it, following our guide, who picked his steps, choosing those drosses to tread upon which were the least friable; but our labour was vain, since, on reaching the looked-for term of our journey, so great a quantity of smoke issued as entirely to fill the mouth of the crater, and prohibit all approach.

"The guide, who had paid a visit to the same spot some days before, informed me that he perceived a considerable increase in the fermentation of the mountain; and what he stated was confirmed by a smoke, which ascended from a number of the chasms of *Monte Rosso*, although this mountain is at a distance of three miles from the crater.

"Before I quitted the lava, I placed the thermometer on a piece of heavy dross, about the middle of the current; the mercury, in two minutes, rose to 22½ (72½ Fahrenheit*).

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* "The difficulty of the situation did not admit of my making experiments with the electrometer; but on examining this instrument, at the distance of a mile from the crater, I found the divergency of the balls extended to three lines and a fraction; this I then perceived to be owing to a cloud, which was passing perpendicularly over my head; when the foot of the electrometer touched the earth, the electricity disappeared; and repeating afterwards the experiment, I found the divergency did not exceed one line."

"Directing now my steps towards that part of the cone which fronts the south, I found there another small current which had not, like the rest, proceeded from the crater, but which, on the 18th of July, formed an opening for itself, half a mile below the crater; this eruption had formed a small mountain of a conic form, with a lateral opening, through which the current flowed in a breadth of half a mile, and to the length of a mile. My guide informed me, that it was from the inferior opening of this small cone that the smoke, mixed with sand and light drosses, issued, which occasionally concealed the fire from the great crater.

"This partial eruption was not visible from Catania, on account of the interposition of *Monte Rosso*, immediately between the summit of Etna and that city.

"The appearance of these two small streams is not so horrible as that of *Bronte*, on account of their being of different colours, produced by the iron in the lava; which is deprived of its inflammable substance by the sulphuric acid, rendered more effective by heat.

"I examined many insulated pieces, darted to the distance of one or two miles, and remarked their figure to be a pretty regular oval; their larger diameter was five, and their smaller three feet; I found a similar block projected the distance of three miles, its diameter one way was eight, the other four feet; its prodigious weight had occasioned it to bury itself almost entirely in the drosses, and its surface alone was visible.

"Pieces of such great bulk are not numerous; but it is impossible to calculate the immense quantity of light and heavy drosses, which, at various elevations, cover the cone itself, and the country for several miles around; and which, during the most violent part of the eruption, fell in the form of rain. The streams of solid lava added together would form a solid mass, including interstices between the parted streams, of *6,218,661,276* cubic feet.

"*PRODUCTION OF THE ERUPTIONS OF THE MONTH OF JULY*, 1787.

"I have minutely examined the productions of this eruption, which may be reduced to the following varieties.

Drosses and powders.

"No. I. The first rain of volcanic matter, at first sight, appeared to consist of a yellowish puzzolana, such as is found near the craters of volcanoes, after their having been long extinct; it is composed of pieces from the size of dice down to that of the finest powder; and is a porous lava, light, tender, and somewhat resembling an argillaceous substance, which is astringent to the tongue; some of the grains are hard lava, heavy, ferruginous, and in round particles. Nearly half of this first volcanic rain consisted of very fine powders; these, seen through a microscope, appear to be composed, 1. of crystals of black schorl*, which partially retain their prismatic shape, and are partially eaten by rust; 2. vitreous grains of similar schorl; 3. grains of lava which have undergone alteration, and are reddened or whitened by vapour; 4. crystals of felspar, detached, and although somewhat decomposed, preserving their rhomboidal form; 5. other crystals of felspar adhering to lava, changed and covered with farina externally, but internally untouched; 6. fragments of lava with small crystals, similar to the arsenical ruby; 7. others incrusted with flowers of sulphur; 8. vitrifactions of no regular figure, porous vitrifactions, and a species of black glass or obsidian, transparent at the edges and of a dark green colour.

"The matter here analysed was collected on the snows of the crater at Trifoglietto.

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* Schorl was then a name for siderite, or hornblende.—P.

"No. II. Heavy drosses of nearly an oval shape, and weighing from six to eight and nine pounds; such were projected the distance of four miles from the crater; superficially they are vitrified, their pores are glossy, and are five or six lines in diameter. The centre of these drosses has rounded and pretty regular pores; it contains crystals of white felspar confusedly dispersed, and some volcanic chrysolites. The crystals of felspar preserve their transparency, and are merely a little glazed, while the chrysolites have undergone a species of fusion, which has combined their grains, and rendered their surface convex.

"These drosses are found round the crater, especially from the southern to the eastern side, as well as in the valley of *Bue*.

"No. III. Light whitish drosses, similar to the cavernous pumice-stone of Lipari; they have the same fibrous texture and prolonged pores; some little light drosses, of a black colour, adhere to this pumice, which separately floats on the water, but which when attached to the black drosses, is carried by their gravity to the bottom: this is the first instance known of Etna having produced a similar substance.

"Found on the W. S. W. torrent of lava, near the crater.

"No. IV. Light drosses in separate pieces; the largest are ten inches long, one in width, and two in breadth; from this size they diminish to that of a pigeon's-egg; their pores are rounded, glossy, vitrified, and of a pitch *black*; some of them seem to be damp as soot; seen through a magnifying-glass, they appear a real vitrifaction, porous, and of a greenish colour.

"These drosses are found at a greater distance from the crater than the former; some even as far from it as six miles.

Sand. "No. V. A very fine and *shining* sand, which, seen through a microscope, is found to be composed of grains of volcanic chrysolites, transparent, and of a golden green, and greenish colour. Among the sand also are fragments of transparent quartz, and laminated felspar.

"Sand of this description fell at Catania, on the 18th of July.

"No. VI. Light sand, formed of small grains and filaments of a glossy vitrifaction, analogous to the drosses No. IV.

"This sand fell in every part of the second region; and on the confines of the first, from the eastward to the south and south-east, on the 18th of July; it is mingled with fragments of the drosses before noticed.

"No. VII. Puzzolana composed half of crystals of black schorl, which have received a kind of varnish from fire; of fragments of drosses such as described No. III.; of chrysolites, some yellow and transparent, and others opake and of dull green colour at their edges; of small crystals of white felspar in rhomboidal laminæ, some detached, others united together, and grouped with crystals of schorl, some of them superficially vitrified. The crystals of schorl preserve almost perfectly their natural figure: they are chiefly detached in octagonal prisms, somewhat compressed, and with two broad and one narrow side, terminated by a dyedral summit with hexagonal faces; they present some slight varieties.

"This matter, which fell on the 19th of July, did not extend beyond the middle region, where it spread from the S. E. by S. to the S. W. wherever the watery cloud mixed with the smoke which contained it was carried, and from which it was precipitated by the rain.

Pebbles of lava.

"No. VIII. Pieces of lava tolerably compact, of an oval or wedge-shaped form, from two or three to twelve inches in length, and from one to six inches in thickness; the surface vitrified, and exhibiting small pores; their interior similar to that of No. II. They resemble pebbles rounded by water, and are remarkable among the drosses, amid which they are found, on account of their singular shape.

"They are collected on the cone of Etna, lying among light drosses.

"No. IX. Other pieces of the same form, but more compact: the surface of these is more smooth, and is sprinkled with white spots, which seem produced by the vitrifaction of the felspar; the internal part of these pieces assimilates with obsidian.

"These are found in the same place as the last.

"No. X. Oval pieces, nearly two inches in length, composed of two parts of white felspar transparent and glazed, some yellow chrysolites, and some prismatic crystals of black schorl; the surface of this specimen was changed by fire, which had chiefly affected the schorl, occasioning it to lose its angles.

"Found near the crater.

"No. XI. A compound stone, divisible in parts, with a vitreous incrustation: one portion exactly resembling lava, which elicits sparks when struck with steel; the laminæ are distinguished one from the other by their different colours, the result of a calcination which has acted differently on the various component matters; in it mica and felspar are found in an unaltered state. In one of the laminæ are crystals of prismatic schorl; and in all the cavities is a white fibrous radiating matter, which I conceive to be asbestos in a changed condition, owing to the action of fire.

"It is found on the current of lava, at the foot of the cone.

"No. XII. A grey lava with earthy grains, which, notwithstanding, yields sparks with steel; its base is composed of a great number of points and laminæ of felspar, with some crystals of black vitreous and prismatic schorl, and a few grains of greenish chrysolite; this lava, on being moistened, yields a smell like clay, as also do the two following lavas. Lavas.

"It is a result of the lesser eruption towards the south.

"No. XIII. Compact lava showing a vitreous fracture, the base of which consists of small shining points, resembling talc, mingled with diminutive lamellæ of white felspar, and some chrysolites of a dull green colour: this specimen was apparently fissile.

"This proceeds from the same eruption.

"No. XIV. A lava of a dark grey colour, of the same species as the foregoing; it is of rougher grain, and the talc still preserving its lustre has become agglutinated, and compressed by a kind of calcination.

"Its origin similar to the last.

"No. XV. A black lava with a base of felspar and chrysolite, to which fire has imparted different colours; it comprehends rhomboidal crystals of felspar, and crystals of vitreous schorl and mica.

"From the eruption of the west-south-west.

"No. XVI. Lava in beds of different substances: one of them is compact, very hard, of a fine grain, with laminæ of felspar; the other has regular pores, with laminæ of felspar which cross each other, and vitrified grains of a greenish hue and semi-transparent; this lava, on being moistened, yields a strong smell like clay.

"It is a product of the same eruption as the lava of the preceding article.

"No. XVII. A compact and very hard lava, with a vitreous fracture; its black base contains small laminæ of felspar, with a few crystals of vitreous schorl.

"From the same current of lava as the preceding.

"No. XVIII. A very hard and compact lava, black, and sprinkled with points varying in size,

ormed by a black shining glass, which still re-
ains the figure of the crystals of schorl contain-
d in the base, which was on the point of fusing
nto a state of homogenous glass.

"From the same eruption.

"No. XIX. A dark grey lava of a rugged
acture, the base of which contains similar
cales of talc as No. XIII. and No. XIV. with
ome laminæ of felspar faintly apparent.

"Found in large oval masses ejected by the
olcano.

"No. XX. A porous lava, of similar nature
o the preceding, with a stratum of vitrifaction,
ningled with laminæ of mica, radiantly disposed.
rom the same.

"No. XXI. A species of stalactite, or con-
retion, found under the preceding lavas; it pre-
ents three varieties:

"1. With a friable base, and laminæ appa-
ently of mica.

"2. With a coating of silvery talc.

"3. With a coating two lines in thickness,
onsisting of a white powder, which is salt of
edlitz, deprived of its water of crystallisa-
on.

"No. XXII. An incrustation of selenite, of a
ningled white and red colour, in thin strata,

forming a coating of two lines in thickness, on which are small grains of a similar nature*.

"Found in the fissures of the w. s. w. current of lava.

"No. XXIII. Deliquescent sea-salt with a martial basis, which flows from those light drosses which are of a reddish yellow colour.

"From the same fissures.

"No. XXIV. Martial vitriol adhering to many of the preceding drosses, now of a lively red, now of a greenish yellow, and now of other colours: these drosses remain yet partially covered with the selenite of No. XXII.

"From the same spots as the last: in the eruption of this w. s. w. current it was very abundant.

"No. XXV. Martial sal ammoniac, sublimated in very thin needles, two or three lines in length, and adherent to a light cellular lava of a reddish yellow colour: on examining these needles with a microscope, small articulations are clearly distinguished, composed of octaedra, placed one on the other.

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* "These incrustations of selenite are found in very great abundance in the two new currents of lava; they evince the prompt activity and powerful effect of the sulphuric acid on the calcareous molecules of lava, especially when assisted by heat."

"From the same fissures.

"No. XXVI. A hard lava, the base of which contains many small laminæ of felspar and grains of volcanic chrysolite, coloured by fire, and some pretty large clusters of the same kind of chrysolite.

"From the current of lava which flowed towards *Bronte*.

"No. XXVII. A hard, grey, and dullish lava, with abundance of laminæ of felspar, of greater size than in the preceding specimen; they are enveloped in the base of the lava, as well as some crystals of prismatic schorl, and some yellow and greenish chrysolites.

"From the same stream of lava as the preceding.

"The different specimens of lava I have described, show us the nature of the various kinds of primitive stone, which constitute the base of Etna; they demonstrate also that the rocks, which enter into the composition of these eruptions of lava, undergo little change from fire; and that, in the last eruption, the granitoid schist had been chiefly attacked*.

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* "From the indications of the Commander Dolomieu, who has discovered in the Neptunian mountains (or those of Peloro) all the primitive rocks found in the various lavas evolved from Etna, I have myself made a large collection of them; these I have also compared

Ferrara's account of the eruptions 1800, 1809.

The intelligent Ferrara has given a chronology of the eruptions of Etna; but has only described those of 1800 and 1809 in the following words:

"1800. In February, the mountain ejected smoke, with those powders falsely called volcanic cinders and ashes. During the night of the 27th, the inhabitants of Zafarana, situated about the middle of the cone, on the east, were awaked with the horrible explosions of the mountain, and saw rising to a prodigious height immense columns of fire, which often sparkled with long and tortuous lightnings. Their summits expanded, and dropped black matter, which burst on the fire beneath. This phenomenon was accompanied with a tremendous roar, like that of a ruinous hurricane; and a strong west wind which arose, bore to the east all the ejected matter, which formed on the lower skirts rain, sand, and drosses, which, rustling as they fell, occasioned a singular and horrible noise. They deposited a bed half a foot thick. This phenomenon was repeated on the 4th of March; the eruption of inflamed masses was more copious, and the southern wind carried the dust even to Milazzo. The inhabitants of the places in that direction, but more near the volcano, were greatly incommoded with this dreadful shower. At Malvagna, fifteen miles from the crater, the sky suddenly darkened, and the people were obliged to light candles, though it wanted an hour and a half to sunset, as neither business nor pleasure could be followed amidst the thick darkness. It seemed as if the darkest hour of the night had fallen at once; and the inhabitants neither knew where to flee, nor what was the cause, as they only heard a rustling murmur. This uncertainty continued for twenty-five minutes; after which began a rain of black drosses, the largest of which were nine ounces in weight. But at Mojo and Roccella they were of thirteen ounces; and many in the fields received wounds in the head and arms. These drosses had so much heated the atmosphere, that a copious fall of rain-water, which accompanied them, was quite hot.

"The eruption was often repeated in the following months; and the grandeur of the scene was increased by frequent forked lightnings, which broke forth in the midst of the black smoke, having commonly one line perpendicular to the axis of the cone of the crater, while at the other extremity another rose at right angles, and was lost amidst the smoke and the flames. This long eruption ended in July; having formed on all the upper part of the mountain a stratum of many feet of light drosses, into which form the va had been reduced by the intense heat and rmentation.

“ 1802. An eruption from a new aperture, a ttle under the crater, in the great valley of ue, accompanied with horrid thunders and emendous bellowings of the mountain. It eased in a few days, but the lava ran twelve iles.

“ 1809. After the volcano had, in 1805 and 806, ejected flames and copious smoke, at unqual intervals, during which some undulating hakes were observable, chiefly in the skirts, nd after a perfect calm in 1807, during which often descended to the bottom of the crater, nd to spots before inaccessible; in 1808, the equent eruptions of flame returned, the most opious being always preceded by prodigious ellowings of the mountain, and subterraneous hunders, not without some shocks sensibly felt ven at Catania. These having continued till Iarch 1809, on the 27th day of that month, fter the rise of immense perpendicular columns f smoke, was opened a new orifice, a little under he crater towards the N. W., from which issued river of fuliginous smoke, in the form of enorious balls, with a slow motion, as they were full f powders and sand, which were snatched by he wind and carried even to Messina. Afterwards, in a line, which from the third or open region of the mountain passed the woody region till it reached the cultivated lands of Castiglione and Linguagrossa, many new orifices were opened. One was at six miles distance from the first, and the others at unequal distances; while throughout all the space many fissures appeared and subsidencies of the ground. From these new orifices, after they had darted immense clouds of dark smoke, which appeared like horrid rocks hanging in the air, and from which the drosses which fell in iron sleet, rushing and dashing against each other, produced a clamour which filled the neighbourhood with dismay; on the 28th, at the approach of night, were ejected torrents of lava, whilst the mountain suffered the most violent convulsions, and resounded with horrible bellowings, which were heard even as far as Catania. The thunders of these apertures were pretty frequent, and were repeated progressively from one to the other, till they reached the crater. The eruption continued for the remaining days of March, and the beginning of April, when the lava ceased; after having covered a space of eight miles in length, and four hundred and fifty feet in breadth. Around the two chief orifices, in which the fire seemed at last concentrated, were formed two large conical masses of ejected matter, one of them having two summits. The shocks continued to be felt in the succeeding months, but the eastern skirts toward Aci were the most agitated; and in some parts it appeared as if the subterranean winds and vapours would have opened new apertures, struggling as it were to get loose; while on the same spots long fissures appeared, occasioned by the sinking of the ground. But the circle of these great agents of nature seems to have been confined by the mountain; for, in the following months, the shocks arrived at Catania with an undulation which was evidently occasioned by a shock from the north to the south: and afterwards, while Etna remained perfectly quiet, these undulations violently and repeatedly shook many places of the southern part of Sicily, called Valdinoto; and have continued, with still more force and frequency, in the present year 1810."

To return to a more immediate consideration of tufo, as connected with the present design, this important substance may be arranged under the following divisions:

HYPONOME I. HARD TUFO.

This has often the appearance of a grey argillaceous stone, and is used for building in various parts of Italy. It is generally grey and porous, and sometimes contains small leucites, whence this kind is called partridge-eyed tufo[*]. It may also embrace fragments of granite; but when these are numerous, and joined with fragments of marble and other substances, it assumes the name of *peperino*, which is a volcanic bricia, or glutenite.

Micronome 1. Of Clay, Sand, Powder, Pumice, &c.

This is the most usual form of tufo; but the clay seems to be chiefly inserted by the infiltration of the waters from superior soils and eminences.

Tufo, from Herculaneum, Pompeia, Iceland, &c. &c.

Hard tufo, from Mont Anis and Polignac, in Auvergne, where it is used for building.

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[*] Patrin, v. 298. The isle Ventotiene (Dol. Ponces, 41) consists almost entirely of a volcanic tufo, a soft stone with an argillaceous base, including fragments of lava, slags, pumice, &c.

The same, with bitumen and chalcedony, from Clermont.

Micronome 2. Of Dross, and pulverised Lava.

This, in the course of ages, assumes considerable hardness, while it shews its origin by its black colour, arising from the drosses or *scoriæ*; the latter are sometimes red from calcination, whence seems to arise the name of Monte Rosso, ejected by Etna in the terrible eruption of 1669; but the surface at least is chiefly incoherent. This tufo in particular sometimes affects the magnetic needle. Black tufo sometimes resembles wacken.

A tufo of fragments of lava, drosses, sand, augite, and conchitic limestone, in a paste of marl. Ferrara, p. 67.

Micronome 3. With fragments of Granite, or other substances.

When these are numerous and closely set, the stone becomes a volcanic glutenite; but they are sometimes rare and remote.

A tufo of lava and limestone, from Cape Passaro and the rocks of the Cyclops, Sicily*.

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* Ferr. 181.

HYPONOME II. SOFT TUFO.

This is either found in an incoherent form, or easily crumbles into small fragments. When it chiefly consists of comminuted pumice it is called, in its recent state, *lapillo* or *rapillo;* and sometimes, though improperly, *white puzzolana;* for the absence of iron must render it unfit to be used as a cement, which is the chief quality of puzzolana. It sometimes consists of minute scoriæ, or dross, in which case it is called *black puzzolana;* and at Naples a *rapillo;* now constituting, according to Dolomieu, almost all the mountains around Etna, with nine-tenths of that mountain itself*.

Lapillo.

Puzzolana.

The proper puzzolana, also called Trass or Tarras, which is used to consolidate buildings under water, is a ferruginous clay, of a grey, brown, or reddish colour; and is more likely than any of the others to be a muddy ejection from the volcanoes.

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* Dolomieu, Etna, 323, 328. Volcanic scoriæ, like those of a smithy, or more porous, form all the conic mountains around Etna, and perhaps nine-tenths of its mass. At Naples they are called *rapillo.* (Dol. Etna, p. 328.) They are of the nature of lava; while puzzolana is burnt clay. Ferrara, a superior judge, denies the extent of the tufos, and says they do not form one half of Etna: p. 336.

Micronome 1. White Tufo.

This consists, as already mentioned, of comminuted pumice, and often presents larger fragments of that stone. It may, from the various influence of the waters, be indurated in some parts, and incoherent in others.

Micronome 2. Black and red Tufo.

Tufo, of comminuted black dross, from the mountains of Iceland.

The same, from Etna, and its filial hills.

Tufo of small red scoriæ, from Monte Rosso. This mountain, chiefly formed of volcanic sand, is 1000 feet in height.

Micronome 3. Tarras or Puzzolana.

Tarras.

This is chiefly a ferruginous clay, as already explained; but ferruginous tufos in general may be applied to the same purposes. The tarras found near the Rhine is of the same nature and quality; and is supposed, by impartial authors, to be of volcanic origin. A more candid and equitable judge cannot be invoked than the patient and experimental Saussure, who not only allows the mountain of Chenevari, and some others in the south of France, to be of volcanic origin; but has also published an interesting account of his

2,570, which is that of the black, to 2,785, rarely 2,8. Has an earthy smell.

"It is not diffusible in cold water; but in boiling water it gradually deposites a fine earth. It does not effervesce with acids.

"Heated, it assumes a darker colour, and easily melts into a black slag; or, with borax, into a yellowish green glass.

"It is magnetic before it is heated, but not after. This is the most remarkable of its properties.

"By Mr. Bergman's analysis, it contains from 55 to 60 per cent of silex, 19 to 20 of argil, 5 or 6 of lime, and from 15 to 20 of iron. 3 Bergm. p. 194.

"When mixed with a small proportion of lime it quickly hardens, and this induration takes place even under water. This singular property appears to me to proceed from the magnetic state of the iron it contains; for this iron being unoxygenated, subtilly divided, and dispersed through the whole mass, and thus offering a large surface, quickly decomposes the water with which it is mixed when made into mortar, and forms a hard substance analogous to the specular iron ore; as it does in the iron tubes, in which water is decomposed, in Mr. Lavoisier's and Dr. Priestley's experiments. For in these the iron swells and increases in bulk, Mem. Par. 1781, p. 277: and so does puzzolana when formed into mortar, Higgins on Cements, 125. One principal use of lime seems to be to heat the water, as while cold it cannot readily pervade the caked argil that invests the ferruginous particles; yet, in time, even cold water may pervade it, and produce hardness; and hence lavas become harder when moistened, as M. Dolomieu has observed, Ponces, 417. If the mortar be long exposed to the atmosphere, fixed air, as well as pure air, will unite to the iron, rust will be produced, and the mortar will not then harden, as Dr. Higgins has also noticed. Clay, over which lava has flowed, is frequently converted into puzzolana, Ponces, 332. But volcanic scoriæ never afford it; ibid; either because they are much calcined, or retain sulphur, or its acid."

"TRASS OR TARRAS.

"I couple this with puzzolana, on account of their similarity to each other, and not because I look upon it as constantly, and necessarily, a volcanic production. On the contrary, I believe it to be generally the product of pseudo-volcanoes, or external fires.

"It is found in many places, but principally near Andernach, in the vicinity of the Rhine; also near Frankfort, Cologne, Pleith, &c. and there called *tuffstein*.

"Its colour is grey, brown, or yellowish.

"Its surface rough and porous.

"Its lustre and transparency, 0.

"Its fracture, commonly earthy, rarely lamellar; it contains fragments resembling pumice (though not real pumice, Voigt *Fulda*, 221); also fragments of argillite and basaltin (siderite); often branches of trees half cleared, and impressions of leaves, 2 Nose, 182. Mica, iron ore, and other heterogeneities, are more frequent in it than in puzzolana, 3 Bergm. 196.

"Its hardness from 5 to 7.

"Feels dry and harsh. Scarcely effervesces with acids.

"It is not diffusible in cold water; but in hot it gives an earthy smell, and deposites a finer earth.

"It melts into a greyish brown slag.

"It is found in valleys, some feet under the surface, to which no streams of water have had access. Sometimes in columnar masses of a grey, or Isabella yellow colour, some round and some quadrangular, standing close to each other, and forming internally one common mass. 3 Berl. Beob. 199.

"According to Mr. Bergman, it consists of nearly the same principles as puzzolana, only the calcareous seems more plentiful in this.

"Artificial tarras, or puzzolana, is made by burning clays or slates that abound in iron, and then grinding them to a fine powder."*

Of Ireland. A red substance is found in the north of Ireland, particularly in Lord Antrim's Deer-park, near Glenarne, which has a burnt appearance, and much resembles the puzzolana of the extinct volcanoes of France. It might perhaps be applied to architectural purposes. Faujas, who rendered a service to his country in discovering the puzzolanas of Vivarais, gives the following observations†.

Uses of puzzolana. "Puzzolanas are an object of the first utility in hydraulic constructions. We cannot build with solidity in the sea, without using this volcanic production, by mixing it with two portions of lime to one of this natural cement, of which a well-united mortar is formed. Vitruvius has, in his architecture, devoted a chapter to the origin of this substance, and the property it possesses of hardening very soon in sea-water, as well as fresh, when it has been amalgamated with strong lime; it then perfectly resists the corrosive action of marine salt.

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* Kirwan, Min. i. 411.

† Annales du Museum. It is truly surprising that he has omitted this important article in his large Classification of Volcanic Substances. *Geologie*, tome ii. p. 401—678.

"There are in Vivarais, Velay, as well as in Auvergne, as good mines of puzzolana as those of Italy; and yet we still use the puzzolana of the environs of Naples: which shows that much time s necessary to change the customs of men, even n the most simple things.

"The trass of the environs of Andernach, on the left bank of the Rhine, is a kind of puzzolana formed of small fragments of pumice, and several species of lavas, more or less altered and agglutinated in the manner of volcanic tufos*. Trass s transported by water as far as Dort, to be reduced to powder in stamping mills worked by the wind. Trass, thus pulverised, circulates throughout Holland; and is used with the greatest success for all constructions in masonry, in a country where water is every where found in digging the earth: the Dutch also supply England with trass."

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* "I have given the description of the quarries of trass in the irst number of *Annales du Museum*, vol. i."

NOME V. PUMICE.

Former rocks. This substance deserves to be ranged among the rocks, as in the isle of Lipari, whence it is chiefly brought into commerce, it appears in the form of large currents[*]. Pumice also abounds at the smaller volcanoes of the isles of Santarin and Vulcano: and, according to Troil, Hecla presents vast quantities of brown and black pumice. The volcanoes of Ternate, and other Molucca isles, also eject such prodigious quantities of this substance that the ocean appears covered for many leagues.

Chiefly felspar. Different lavas may become pumice by some peculiar modification of the volcanic agents. Felspar in particular has been detected passing into pumice: and according to the degrees of heat and other circumstances, it may be more or less porous and light[†]. That which only presents small cavities may be termed *porous*; while the more lax may be styled *vesicular*.

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[*] Patrin, v. 289, from Dolomieu's Lipari.

[†] Ferrara, p. 304, mentions a large specimen ejected by Etna in 1802, of which one half was lava, or melted siderite, the other pumice or melted felspar. See also his account of the pumices of Lipari, p. 215.

Pumices of Lipari.

In his visit to the little isle of Lipari, which, though only six miles in length and four in breadth, is singularly interesting from the pumices, and great variety of volcanic glasses of all kinds and colours, which it contains, Spallanzani has minutely described this substance; and the spot whence it is exported to all parts of Europe, as it is useful in many of the arts. On such occasions, the words of the original observer are to be preferred, not only for the sake of accuracy, but because the impressions of the scene are best conveyed by a spectator; not to add that they diversify the style, by imparting somewhat of a dramatic interest to the narrative.

Campo Bianco.

"I had now continued my tour in the boat, till I approached Campo Bianco (the White Field), distant three miles from the haven of Lipari, and so called because it is a lofty and extensive mountain, composed entirely of white pumices. When seen at a distance, it excites the idea that it is covered with snow from the summit to the foot. Almost all the pumices that are employed for various purposes in Europe, are brought from this immense mine; and Italian, French, and other vessels continually repair hither to take in cargoes of this commodity: the captain of the ship which had brought me to Lipari, had sailed from Marseilles examine the pumices most suitable to this purpose, and to make further experiments on them after my return to Pavia; which practice I likewise observed with respect to the other volcanic products.

Mountain of pumice.

"Campo Bianco is a mountain that rises almost perpendicularly from the sea, and which seen at a distance appears to be about a quarter of a mile in height, and above half a mile in breadth. No plants grow on it, except a few which bear no fruit, and likewise grow on the tops of the Alps. Its sides are streaked with a great number of furrows, that grow deeper and wider as they approach the bottom, and have been formed by the rains, which easily corrode and excavate a substance so soft and yielding as pumice. The sea at the foot of it has likewise occasioned great devastations, by means of which we discovered a large vein of horizontal lava, on which the last waves die away when the sea becomes calm. The formation of this lava was, therefore, prior to the vast accumulation of pumices which rest upon it.

In beds.

"On attentively viewing this prodigious mass of pumice, we soon perceive that it is not one solid whole, and forming only one solid single piece; but that it is an aggregation of numerous beds or strata of pumices, successively placed on whether the action of the waves might not concur to produce the roundness of their figure, I rather chose to make my observations on those that actually formed the beds; which I did, by climbing up one of the sides where the ascent, though difficult, was not impracticable. Here I found pumices approaching, some more some less, to the globular form; and of different sizes, some not being larger than nuts, and others a foot or more in diameter, with innumerable sizes between these extremes. Though the ground colour of them all is white, in some it inclines to yellow, and in others to grey. They swim in water, do not give sparks with steel, nor cause the least motion in the magnetic needle. Their fracture is dry and rough to the touch; their angles and thinner parts are slightly transparent; and their texture in all of them, when viewed through the lens, appears vitreous; but this texture has diversities, which it will be proper to specify.

Globular.

"Some of these pumices are so compact that the smallest pore is not visible to the eye; nor do they exhibit the least trace of a filamentous nature. When viewed through a lens with a strong light, they appear an irregular accumulation of small flakes of ice; their compactness,

Compact.

however, does not prevent their swimming on the water.

Porous. "Others are full of pores and vacuities of a larger size, usually of a round figure; and their texture is formed by filaments and *streaks*, in general parallel to each other, of a shining *silver* whiteness; and which, at first view, might seem to be silken, did they not present to the touch the usual roughness of the pumice.

"These varieties are not only observable in different globes of pumice, but frequently in the same: it is therefore indubitable *that these* differences are not intrinsical and essential to the nature of pumices; but accidental, and arising from the action of aëriform fluids, which *dilating* them in many places, when they were in a state of fusion, have produced that multitude of pores, and those filaments and subtile streaks that denote a separation of the parts; whereas the other pumices, which have not been acted on by these gases, have preserved that compactness which results from the force of aggregation.

Fracture. "The fractures of the compact pumices are, in some places, shaded with a blackish but at the same time shining tinge; which, when carefully examined, is found to be caused by a greater, though still a very slight, degree of vitrification of the pumice itself; either because the fire has there acted with somewhat more force, or because the parts were there more easily vitrifiable.

"The pumices hitherto described, form one of the species which the Liparese sell to foreign traders.

"None of these, so far as can be discerned by the eye, or even with the assistance of the lens, contain any extraneous bodies; but were we too hastily to conclude that they really do not, we should commit an error, as their vitrification by artificial means will prove. When kept in the furnace during an hour, they become only more friable and of a reddish yellow colour; but when continued in the same heat for a longer time, they condense into a vitreous and semitransparent mass, within which appear a number of small white felspar crystals, that were not visible in the pumice, because they were of the same colour. These stones, however, are not seen in every pumice thus fused; either because it did not contain them, or because they have melted into one homogenous mass with the pumice. This is one of the many important cases in which we are able, by the means of common fire, to discover the composition of volcanic

Effects of heat.

products, which had at first been supposed to be simple.

"But to render complete my enquiries relative to the pumices of Campo Bianco, it was necessary that I should not confine my researches merely to the part of the mountain I have mentioned, but extend them to all the principal places where they might be found. This I did, accompanied by two natives of Lipari, whose assistance was particularly useful to me, as they lived by digging pumice, and were well acquainted with every part of the mountain, and the different kinds of pumices it contained. It is impossible to describe the difficulties I met with in these excursions. We frequently passed along the edges of the deep ditches made by the rain-water, at the hazard, in case of a false step, of falling into them, and not easily getting out again; or the still greater danger of precipitating into the sea. The dazzling whiteness of the pumice, equal to that of snow, increased my fears; for I made my excursions in the day time, when the sun shone, and was strongly reflected by these stones. Every one knows that snow, besides dazzling the sight, is accompanied with the inconvenience, when it is deep and has lately fallen, that the person who walks on it sinks into it to a greater or less depth: and the same inconvenience is experienced from the pumice, which in many parts of Campo Bianco is reduced to a powder several feet deep, and, when the wind blows on it, sinks in on one side, and is heaped up on the other. All these difficulties and obstacles I however surmounted, animated by that ardour which inspires the philosophical traveller, and enables him to brave the greatest dangers, and such as can only be known and appreciated by those who have engaged in similar undertakings. I can affirm, therefore, with great satisfaction, that with the assistance and guidance of the two Liparese, there was no corner of the mountain that I did not visit; and when I reached the summit, and saw that it joined another mountain, the foot of which was in the sea, and which was in like manner composed of pumice, I extended my researches to that likewise, and examined the different species of pumice it afforded, or rather which compose a very considerable part of it. I shall proceed to describe them severally, with as much brevity as possible.

Varieties.

"I shall first mention those which constitute a branch of commerce at Lipari, and are applied to various purposes. One of these has already been sufficiently described: I shall only add, that it is found in considerable quantities in Campo Bianco; but solely in detached pieces, and not forming currents or veins; whence it is evident that it has been ejected from the volcano, and has not flowed in the manner of lava.

"The second species is cut by the labourers in parallelopipeds, about twenty-two inches long and eight broad. This pumice is of a dark dirty colour, contains no extraneous bodies, gives a few sparks with steel, and is so light that some pieces of it will float on the water. It is formed by agglomeration of pumiceous bubbles, which are, as it were, conglutinated together, and *incline* more or less to an oblong figure. To detail their various sizes would be useless prolixity. I shall only say, that from the very minute and, if I may so term them, infinitesimal, they increase in size till some of them exceed an inch in diameter, though the latter are less numerous than the former. They are all extremely friable, as their sides are very thin, and always semi-vitreous. The glass of many of them is white, and has some transparency; but in others is dull, and almost entirely opake.

"As I do not know that this species of pumice has ever been described before, though it certainly well deserves attention, I would wish my description to be as clear and explicit as possible. It has been already said, that many lavas, and other volcanic productions, on re-fusion, become cellular. To apply this to the pumice in question, would be an error. A lava, which has undergone this change by the action of elastic gases, continues to form one whole, though interrupted by these multiplied pores. The pumice of which I now speak is principally formed by an accumulation of small vitreous vesicles, which attached themselves to each other while they were yet soft from the action of the fire; and which, from their globose figure, not adhering except in a few points, have left many vacuities very visible in the fracture of the pieces. The labourers who dig these pumices, after they have shaped them into parallelopipeds, take them on their backs and carry them down to the shore, where they pile them up in large heaps, to be ready for sale when opportunity shall offer. We are not to imagine, however, that this species of pumice is to be found in every part of the mountain: the workmen, to find what they call the vein of it, are obliged to make great excavations, and frequently without success; which, as they told me, in this case, as in fishing for coral, often depends on chance. When they have found the vein, they dig it, following its direction; in which laborious employment a number of men are occupied for whole weeks, the vein being sometimes a hundred and fifty, two hundred, or even three hundred feet long, and large in proportion. These veins are called *Faràglioni*. I have examined them, and satisfied myself that the accounts I received were true. Pumice-dust, and large heaps of the first species of pumice, with some scattered vitrifications, usually cover these veins, which, when viewed with the attentive eye of the naturalist, give reason to believe that they are long tracts of pumice, which once flowed in a liquid state. Their bubbles, frequently lengthened in the direction of the vein, seem likewise to prove the same.

Currents.

"M. Dolomieu, who first suggested that many pumices have flowed in currents like lavas, observed that at Campo Bianco the lighter pumices lie above the heavier; in the same manner as in the common currents of lava, the porous lavas occupy the highest place. I have certainly observed this disposition; but sometimes it proves fallacious: for if the excavation be continued below the vein which forms the second species of pumice, we frequently again find masses of extremely light and pulverulent pumice.

"The first action of the fire of the furnace thickens the sides of the vitreous vesicles, of the second species, and diminishes the internal pores. A longer continued heat entirely annihilates the pores, and changes the pumice into a fixed, obscure, homogenous, and hard glass, which gives sparks plentifully with steel.

Another kind.

"The third species is likewise an object of traffic with the natives of the island, who dig it in the same places where they find the second; and, in like manner, shape it into parallelopipedons. This is likewise an aggregate of bubbles, but differing from those of the former in several respects. Those, as we have seen, are conglutinated together in some points, while they are separated in others, so that we can frequently detach them without breaking; while these, on the contrary, are so incorporated by different solid points, that if we attempt the separation of one, we break the others that are contiguous. Here the elastic gases, investing the pumiceous substance in several points, have expanded it in every part into tumours and cavities, nearly as we see in raised and baked paste. It is worthy remark, that frequently when we break one vesicle, we meet with another within it, and concentrical. There is likewise another difference between these two pumices. The vesicles of the second species are all more or less vitrified; but many of the third show no signs of vitrification, are extremely friable, and of a pale red colour.

"This pumice, though destitute of any fibrous texture, is specifically lighter than water. To obtain it, large pieces of white pumice, of the first species, in which it is enveloped, must be removed; and it commonly lies in long tracts, in the direction of which its vesicles are sometimes lengthened, which may induce us to suspect that this likewise, when it was liquid, formed small currents. It contains no extraneous bodies.

"In the furnace it condenses into an obscure mass of glass, almost opake, but little porous, and sufficiently hard to give sparks with steel.

"These are the three kinds of pumice which the people of Lipari dig for sale. The first is employed in polishing different substances; and the other two are used in the construction of arched vaults, and the corners of buildings."

From these descriptions the following arrangement naturally arises.

HYPONOME I. POROUS PUMICE.

From Lipari. It sometimes presents small crystals of felspar.

Porous pumice, from Hecla.

HYPONOME II. VESICULAR PUMICE.

From Lipari, Santorin, Hecla, Ternate, &c.

Micronome 1. Fibrous felsite.

This kind of pumice, described by Dolomieu, assumes the form of distinct elongated fibres, and sometimes occurs with minute crystals of felspar.

NOME VI. OBSIDIAN.

This division will include all the Volcanic Glasses and Amels*; which are nearly connected, and often pass into each other.

The volcanic glass called obsidian, appears in such quantities as to constitute rocks.

Patrin's account. Lipari.

"In the Isle of Lipari, the mountain *della Castagna* is wholly composed of glass and amels. It forms a promontory which extends 800 fathoms into the sea, and which is more than 3000 in circumference. Spallanzani says, that this mass of vitrified substances cannot be better compared than to a great river, which, dividing itself into a thousand branches, should be precipitated by a rapid declivity, and suddenly frozen. There are several currents, one above another; their thickness varying, in the same current, from one foot to twelve.

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* See Johnson, as before mentioned: *enamel* is properly the application of the *amel* to another substance.

"Some of these substances are *compact*; others are so porous that they resemble *froth*, and float on water. In the cavities of some are observed capillary threads perfectly vitrified.

"As the volcanoes of Lipari have ceased to be active, even before the times of history, these glassy substances must have existed more than 3000 years; and they have not undergone the least alteration.

"All volcanoes do not produce *these vitreous* substances: they are extremely rare in the ejections of Etna, as well as in most countries of Europe.

France. "Faujas only found obsidian in one place in France; at Chenavari near Rochemaure, in Vivarais; and there were but three pieces which he collected. It is an amel, perfectly black, *with* rounded vesicles of about half a line diameter.

Iceland. "The volcanoes of Iceland are very prolific in vitreous substances; and what is improperly called Iceland agate, is a volcanic amel, of a fine black, almost free from pores, and susceptible of a perfect polish.

"The *piedra de Galinazzo*, regarded by Caylus as the obsidian of the ancients, is a volcanic amel of the province of Quito.

Bourbon.

"The volcano of the isle of Bourbon presents very remarkable vitreous ejections: they are filaments of a flexible and yellowish glass, two or three feet in length, sprinkled at intervals with small globules. These threads of glass showed themselves in the eruptions of the 14th of May 1766, and the 17th of July 1791. In the latter, they were carried by the winds, and strewed upon the trees, to the distance of ten leagues.

Marikan.

"The ancient volcanoes of northern Asia have also produced vitreous substances. Near the port of Okhotsk, in the gulf of Kamschatka, there is a volcanic hill called Marikan, formed of a white sand entirely vitreous; and in which are found dispersed, globules of glass and volcanic amel. This very remarkable sand appears at first view to be shelly; for it is all composed of white fragments, resembling mother of pearl, convex on one side and concave on the other. These fragments proceed from the remains of a singular variety of vitreous globules: they are at most of the size of a pea, of a pearly white, perfectly spherical, and exactly like pearls. They are entirely composed of concentric layers, as thin as the peel of an onion, and which separate from each other. They are

Raven-stone.

The *Piedra de Galinazzo*, above mentioned by M. Patrin, is a kind of obsidian found in Quito and Peru; and is so called, because in blackness it resembles the *raven*. It seems to have been sometimes polished, and used for mirrors; but must not be confounded with *the stone of the Incas*, found in the female tombs, and used for the same purpose; the latter being a compact pyrites, or marcasite of the Arabians, and other early writers on mineralogy.

Glasses of Lipari.

In his account of the island of Lipari, after having mentioned several kinds of volcanic glass, as the pumiceous, reticulated, and capillary, Spallanzani thus proceeds, having apologised for the prolixity of his description as indispensably necessary for the sake of accuracy, in discussions merely scientific.

Spallanzani's account.

"4. The glasses of the Monte della Castagna, which we have hitherto considered, are those that have a texture more or less porous; we will now proceed to those of a compact structure, of which kind is the fourth species, which may be said to compose nearly one half of the mountain. This glass, if viewed superficially, and as it is found on the spot, has rather the appearance of a red earth than a glass, occasioned by a red earthy coating that invests the glass disposed under it in immense plates; which covering, though in many places it but feebly adheres to it, since it may be removed by simply washing with water, in others is so closely united that it forms the last rind or outermost part of the glass, which induces me to believe that *it is* a superficial decomposition of it. Beneath this earthy coating the glass appears, which is extremely perfect, and as if it had just come out of the volcano. If we except a few pieces, in which its structure is spungy, it is extremely compact and solid, and therefore much heavier than either of the other three kinds. It is of an olive colour, and transparent when in thin scales, examined by a bright light; but in the mass it appears opake. It gives sparks rather plentifully with steel. Pieces of perfect glass, it is well known, when broken, have their fractures striated, waving, and curved. In this glass some of the fractures are the same; but in general they are conchoids, like those of flints. Its consistence is not perfectly homogenous, as it contains many felspathose points. Its aspect is not lively and brilliant, like that of glass, but somewhat unctuous and dull; from all these qualities, this product appears to be more properly an enamel than a glass; unless we are willing to consider it as one of those volcanic bodies which constitute the middle substance between enamels and glasses.

Venular.

"In my description of the glasses of Lipari, I have observed that several of them are intersected with veins or earthy leaves, by means of which they are easily divided into plates. The same is observable in the present glass, in which we find the same quality as in some marbles, which being cut in the vein may be divided, without any great labour, into large slabs, but which break into small pieces if it be attempted to divide them in any other manner. Some of the workmen who dig the pumices, and were very useful companions to me in my excursions to Campo Bianco and the Monte della Castagna, at my request drove, with heavy hammers, an iron wedge into these earthy veins, and extracted from the common mass of this glass, large plates five feet long, three broad, and two in thickness. To the surface of each plate was attached a coating of hard earthy matter, which still more confirmed me in the opinion I have already given, that this matter had resisted fusion, and, being lighter than the fluid glass, had ascended to the surface; a conjecture further corroborated by the artificial fusion which I made of this glass retaining some portion of this earth, which with difficulty fused, though the glass was inflated, and changed into a frothy enamel.

"This glass slightly cuts the factitious glass; and if the cutting angle of one piece is driven with force along the surface of another, it produces a white and impalpable powder.

True obsidian.

"5. This species of glass completely deserves that appellation, since it is not only the most perfect of all the volcanic glasses of the Eolian isles, but does not in the least respect yield to what is called the Iceland agate, or the pietra di galinazzo of Peru, which is supposed to have been the obsidian stone of the ancients. In the large pieces its colour is extremely black, and it is entirely opake, but the thin leaves are white and transparent: the opacity and blackness may be said to be in the direct ratio of the thickness. This glass, which is extremely compact, is free from aëriform bubbles, and from every kind of heterogenousness. It is somewhat harder than the fourth species, and therefore cuts factitious glass more easily, and gives more sparks with steel. Its edges are sharp and cutting.

"M. Faujas, having obtained some specimens of the best glass of Lipari, has made some observations on it proper to be given here. He admits that this species is the same with that of

Iceland; but he remarks, however, that it differs from it in the polish, which appeared to him more unctuous and less vitreous, besides that in the fractures it had not that waving, striated, scaly appearance, which is proper to the masses of true glass.

"It must be remembered, however, that the specimens of M. Faujas were none of the best: the pieces, at least, which I collected, took so exquisite a polish and lustre, that I do not believe any kind of artificial glass ever received one more beautiful and brilliant. This glass, besides, when in the mass, being opake, became a true mirror; and I therefore find no difficulty in believing that the ancient Peruvians used a similar kind of glass, cut and polished, for mirrors*. This glass likewise could not be broken without exhibiting the undulating scales, lightly striated, which the French vulcanist affirms he could not find in his specimens. While I now write, I have before me a piece with a recent fracture, in which these waves are circular and concentrical, occupying an area of two inches and a half, the common centre of which is the point that received the blow: they resemble in some manner those waves which a stone pro-

Polish.

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* It was rather the stone of the Incas, a compact pyrites. P.

when exposed to the fire, melts with difficulty, without the addition of some other substance as a flux. In this it differs from the present of Lipari, which soon begins to soften in the furnace, and in a few hours undergoes a complete fusion.

"This kind of glass, however, is not the most common to be met with on the Monte della Castagna. It is found only in a few places, scattered in large but solitary masses; nor can I pretend to say whether these are remains of currents, or whether they were thrown out by the burning gulfs.

Mixed.

"It happens to this glass as to the different kinds of precious stones, that is, the same piece is not always throughout of equal purity and value; for on breaking some of these masses we sometimes find one portion very pure glass, such as has been already described, and the other imperfect; either because the fusion has not been general, the substance containing bodies foreign to the base, or because that base is rather an enamel than vitreous. These bodies are felspars, but of a new appearance. Nothing is more common than to find felspars in lavas, and sometimes even in enamels and glasses; of which we have frequent examples in this work, as well as in the accounts of other writers: but

Felspars.

these felspars are always inserted immediately into these substances without any intervening body. Here, however, the case is different; every felspar is surrounded with a rind or coating, which, when it is extracted entire from the enamel, appears to be a vitreous globule, about one or two lines in diameter, of a clear cinereous colour. If we break this globule, we find within it the half-fused felspar, not divested of its coating, but forming one body with it. These globules are very numerous, and sometimes by their confluence form groups; and they are very distinctly visible, on account of the black colour of the enamel.

Coating.

"The manner in which this coating was formed around the felspars, I conceive to be as follows: when the enamel was fluid, and enclosed the felspars, it acted as a flux to their external parts, and combined with them; and from this combination was the rind or coating produced, while the internal part of the felspars had only undergone a semifusion, because it was not in immediate contact with the enamel. There can be little doubt but that the felspars likewise existed in the perfect glass; but the heat probably being more active in that than in the enamel, they were completely dissolved, and the entire mass reduced to one similar consistence. As a proof of this conjecture the furnace produced a complete homogeneity of parts in the enamel containing these extraneous globules.

"6. When treating of the rocks of the castle of Lipari, I said they were formed of a cinereous lava of a felspar base, which in many places has passed into glass. I likewise remarked that the lava, as well as the large pieces of glass, was filled with globules apparently not dissimilar to the base. At the beginning of the Monte della Castagna, not far from a cottage, the habitation of one of the labourers who dig pumice, there is a current of similar glass that falls into the sea in several branches, and which I shall here consider as the sixth species. This glass, however, has a more fine and shining grain, and its fracture is exactly such as we observe in glass, yet in beauty it is little inferior to the fifth kind; and if whiteness, or more properly the want of colour, is particularly valuable in volcanic glasses (since those which have this quality are extremely rare), this certainly has considerable claim to our attention: not that it is entirely colourless, as it contains a kind of obscure cloud, which gives it, when viewed in the mass, a blackish hue, but at the edges it appears white. The round cinereous bodies with which it is filled form the most pleasing and conspicuous

Current of glass.

contrast, and render the glass irregularly spotted. I have large pieces of the fifth sort cut and polished: their colour, which is that of pitch, gives them a peculiar beauty. The blackest and choicest marbles of Varena and Verona are far inferior to them in fineness of grain and lustre; yet, from their uniformity of colour, they are less beautiful than this spotted glass, when it has received a delicate polish from the hands of the artist. On the shore, where the torrent fell into the sea, we find pieces of all sizes, rounded and smoothed by the continual agitation of the sea: I have met with more than one of half a foot and a foot in diameter. Notwithstanding the powerful action of the waves, which have beaten on them for so long a time, their internal parts are not injured; and, when cut and polished, they present surfaces very beautiful to the eye. Tablets of this kind of glass (and there is no want of pieces of a proper size to form them) would add much to the grandeur and splendour of any sumptuous gallery.

Origin. "But disregarding the beauty which delights the eye, let us proceed to objects that attract and interest the curiosity of the philosophical inquirer. We shall find that the cinereous bodies included in this glass are only points of lava with a felspar base; and on examining in various places the current of this glass, we shall perceive that it is a continuation of the same lava with the felspar base, of which these orbicular corpuscles are composed; whence we shall not hesitate to conclude, that from this stone both the lava and the glass derive their origin, and that we find small particles of lava scattered through the latter, because it has not undergone complete fusion; whence we find some pieces composed partly of glass and partly of this same lava. In some of these pieces we discover small geodes, or thin filaments of an extremely brilliant and transparent glass, resembling in miniature the husk of the chesnut.

"7. Though this glass in many particulars resembles the last species, it yet differs from it in others. It is perfect, like that, but it is of a deeper colour. In it, likewise, the small globules abound, but they are earthy and pulverisable; every one is detached in its distinct niche, or at most is only fastened to it by a few points.

"The description of this seventh species of glass will render that of several others unnecessary, since the glasses I should have to describe contain a greater or less number of similar globules, differing only in the nature of the base enclosing them, which in some is more, and in others less vitreous. I shall only make one observation, which I think to be of some importance, relative to the glasses I here omit. Several of them have, even in their internal parts, fissures frequently an inch in breadth, and three inches in length. These are not *entirely* vacuities, but are frequently crossed by small *threads* of glass, connected at their two extremities with the sides. The broadest of these threads are four lines in breadth, and the narrowest scarcely a line. When broken they have the fragility of glass, and are found to be a most perfect glass, being colourless, and extremely *transparent*. It is easy to conceive that these threads have been formed in the same manner with those of the capillary glass, found in similar fissures in the third species of glass.

Filaments.

"8. The eighth and last kind of the vitrifications of the Monte della Castagna may be denominated an enamel, that has the colour and lustre of asphaltum, of a scaly grain, a very small degree of transparency in the points of the fractures, and of considerable weight and compactness, though it is extremely *friable*. It is found in solitary masses, not very numerous, and the broken pieces have the property of assuming a globose form. Some of these globes resemble those found by M. Dolomieu in the island of Ponza. I have been favoured with two

Unctuous.

of the latter by the Abbé Fortis; but I find that, excepting their globose figure, they differ in every respect from those of which I now speak. The globes of Ponza are composed of leaves over leaves of an imperfect enamel, do not give sparks with steel, and contain felspars and mica; whereas those of the Monte della Castagna rarely include a few felspars, give sparks with steel, have a vitreous appearance, and are not composed of plates or leaves.

"Some pieces of this enamel, broken and detached from the masses, are in one part true enamel, and in another lava. The latter gives a few sparks with steel, has a grain approaching to earthy, and, as far as I could discover, has for its base a soft horn-stone, from which consequently the enamel likewise derives its origin.

"These are the principal vitrifications I observed in my excursions to the Monte della Castagna. Some I have omitted to notice, since, some trifling differences excepted, they are essentially the same with those described. It is proper, however, to remark, that more than one of them exhibits manifest signs of having once flowed down the sides of the mountain, in the thick threads and vitreous filaments they contain, similar to those we see, on a lesser scale, in glass fused in our furnaces, when it comes

Currents.

fied trap or basaltin. The white fibrous veins sometimes observable seem also to be of felspar, which when heated assumes a fibrous form.

But obsidian also occurs of other colours, such as bluish, dark green, yellowish, and grey; nay, Troil says that in Iceland it is sometimes found colourless, like crystal. Dolomieu mentions a yellow vitreous lava, with black mica and white quartz, somewhat resembling pitch-stone, and which seems a granite in a particular period of fusion. In the eruption of Etna, 1787, a vitreous lava appeared, interspersed with particles of talc*.

The volcanoes of New Spain sometimes present a beautiful obsidian, in which a spangled light plays upon a brown base, with an effect resembling aventurine.

Micronome 1. Entire. Common black obsidian, from Iceland, commonly called Icelandic agate.

The same, from Peru, *piedra de Galinazzo.*

Bluish obsidian, from Iceland, Teneriffe, &c.

Yellowish, from Lipari.

Crystalline, from Iceland.

Refulgent, from New Spain.

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* Dolomieu Ponces, 93, Etna, 509.

ful glass was discovered at Lipari by Spallanzani.

"Black volcanic glass, rather porous, enamelled with reticular lines of white felspar, which every where penetrate it, and cross each other in different directions: the black part is melted, the felspar is only a frit.

"On the summit of Mont Meisner, in Hessia, are found isolated blocks, of a large bulk, of this stony substance, whose base is incontestably vitrified; while the felspar has undergone but a slight alteration. There is nothing extraordinary in this fact, since the obsidians of Lipari not only afford us a similar example, but also show us the felspar in its state of crystallisation.

"It is nevertheless proper to observe, that the crystallised felspar, in the obsidian of Lipari and other places, is an indication that this obsidian owes its origin to a porphyritic rock, whose base should be a trap, or a paste of felspar in mass; while the reticular felspar of the volcanic glass of Mont Meisner seems to differ in its origin, and to have had a base different from porphyries.

"The disposition of this felspar, interwoven in a vitreous black substance, recalled to my recollection some stones which are not volcanic, of a similar texture, which I possess in my collection of rocks. I carefully examined them, and I per-

The remarkable isle of Pentellaria, between Sicily and Africa (the ancient Cossura, of which there are coins), produces a black obsidian of so unctuous an aspect that Ferrara compares it to the bitumen of Chaldea. It is perfectly opake, even in the thin edges; and has numerous crystals and quadrilateral plates of felspar in perfect preservation, except that it has a dry aspect, and is *stunned* in some parts. The pieces more free from felspar are extremely hard, with a conchoidal and often a striated fracture like common glass. When rubbed they yield a powerful smell of burnt hair[*].

HYPONOME VII. VOLCANIC AMELS.

Description by Faujas.

Faujas, in his classification of volcanic products, has so amply treated this curious subject, that his account deserves to be translated, for the benefit of the English reader[†].

"When compact lavas, either prismatic or amorphous, are fused in a crucible in the furnace duced by subterranean fires, this difference only relates to a greater opacity, and a more unctuous and resinous aspect which amels possess; while the glasses, of whatever colour, have a brighter lustre, are more crystalline, and seem better melted.

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[*] Ferr. 258; *odore di capelli bruciati.* Would this express the undefinable smell of quartz?

[†] *Annales du Museum:* but much altered and greatly enlarged in he second volume of his *Essai de Geologie,* Paris, 1809, 8vo. At irst there were seven, but now twelve, classes, injudiciously chosen nd arranged from trifling objects and circumstances; while some portant substances are omitted. But there are many novelties, nd ingenious observations, as usual, in the works of Faujas.

The former edition is preferred, for the reason already assigned.

"Real pitchstones, whatever may be their colour and their vitreous appearance, must not be confounded with glasses and amels: they are foreign to them.

Amels.

"1. Grey amel, with shades of a grey white, rather greenish, with a fracture rather stony than vitreous. Its contexture, and the vesicles seen in its paste, leave no doubt of its being a volcanic amel. In observing it with a lens, crystals of felspar, which characterise its porphyritic origin, are even perceived. This variety comes from Ascension Island, where it was collected by M. de Berth, an able mineralogist, who has some fine collections of lavas from the isles of Bourbon and France.

"2. A yellowish grey amel, rather reddish, with a resinous fracture. If I may be allowed to use the expression, it is what Dolomieu has called *resiniform lava*. Its grain, its fracture, its semi-vitreous paste, all indicate its being an amel; and the crystals of felspar, distinguished on polished faces, announce that this amel owes its origin to of obsidian to black volcanic glasses*, whatever may be their opacity and their brilliancy, more or less unctuous, or their paste more or less vitreous, provided that their transparency is visible on their edges in the thinnest fractures of these glasses. The preceding number forms the transition of black amel to the obsidian of the Ascension Island, of Teneriffe, of Stromboli, Vulcano, &c."

NOME VII. VOLCANIC INTRITE.

This denomination, as in the other divisions, includes those substances which, on a base, present crystals of various natures; and which have thence often been vaguely styled porphyries. Real porphyritic lava has already been considered, under the Nome Compact Lava; being one of the most common appearances of that kind, and scarcely distinguishable from genuine porphyry, with a base of basaltin and crystals of felspar.

The most remarkable and singular volcanic intrite is that with leucite, a crystal resembling a white garnet, and at first so named, which seems peculiar to the lavas of Vesuvius, and of With leucite.

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* Obsidian may be of several colours, as already mentioned.

of its mouth; but occasionally it is much encumbered, and sometimes totally clogged. In 1755, the bottom of the funnel rose so considerably that it presented a vast plain, only 23 feet beneath the brim; and in the midst of this plain was another cone, from 80 to 90 feet high, with a small crater from which the eruptions proceeded.

State of crater, 1631.

" Braccini has left us a curious description of the state of the crater of Vesuvius, after a long state of rest, and before the grand eruption of 1631. The whole of it, or at least its greater part, had become accessible. Having himself descended into the crater, he says he found it covered with plants and trees, and that a road down it was practicable for the space of a mile; that at this depth a very deep cavern was seen, which having passed, the way was again open for two miles, by a very steep, but at the same time very safe road, owing to the trees growing near to each other. At length a large plain presented itself, surrounded by a number of grottoes and caverns, which might be entered, but which the party were deterred from, on account of their darkness. This plain, which was not accessible otherwise than by a very rapid slope nearly three miles in length, must, assurverse. It is therefore probable that these fumes are the production of substances, in the neighbourhood of the brim of the crater, in a state of decomposition.

"When the mouth of Vesuvius is observed from any distance, and during the prevalence of moisture in the atmosphere, a mass of vapour seems to rise from it which mingles with the clouds. Entirely distinct from any volcanic cause, these are only the humid vapours in the air, attracted by the conical shape of the mountain, and imprisoned in the vast cavity of the cauldron. Vapours which spring from, or are diffused over a plain, are dissipated by the air and winds; but when enclosed, they are much less readily dispersed.

Somma.

"The western portion of Somma must be considered as connected with the cone of Vesuvius, by a hill of smaller eminence, denominated *Monte Cantaroni*, on which is the hermitage *del Salvatore*. This hill is intersected by three valleys that deserve to be examined with attention, on account of the quantity of primitive substances which the volcano has thrown thither, during old eruptions. The northern valley is that termed *La Fossa di Pharaone* near the plain, and *Vallone della Vetrana* in its more elevated part, where the current of lava flowed in 1785.

Valleys.

tains but few fragments of augite or pyroxene, and seems to be an assemblage of leucites, the superficial crystalline lustre of which, having been impaired by decomposition, makes it resemble variolite in its exterior. Many detached masses of this current have fallen to the bottom of the valley. Each fall of matter brings down calcareous stones, mica, mixtures of felspar, and idocrases. The lava of 1767, which threatened the villages of La Barra and Saint Jorio, discharged itself into this valley, which it filled to a certain height, and afterwards flowed, spreading itself, to the plain. As it is already covered by the crumblings from the flank, in order to examine it the inquirer must repair to the plain of Saint Jorio, in the neighbourhood of the chapel of Saint Vito. Its grain is crystallised but fine, and oftentimes so close and compact as to be nearly equal to petro-silex. It contains many small crystals of pyroxene, and fragments of leucite, which is rarely found in its perfect form of crystallisation . . . .

Lava of leucites.

"The lava of La Scala passes beneath the garden of La Favorita. It is of the colour of ashes, whitish, and of a crystallised grain. It contains many crystals of pyroxene, few of leucite, and small pieces of felspar, in groups in its cavities. This lava, where it is hewn on the sea-shore near

Lava of La Scala.

test of reason. I merely give my observations, with the reflections they suggest. Geologists are not yet of one opinion respecting the stratification of granite, although it appears to be clearly demonstrated by the observations of Saussure. Admitting, however, the truth of the problem, solid reasons may thence be deduced for believing that the circumstance is more indebted for its existence to a state of aqueous than to one of igneous fluidity: here, however, is a current of hard and compact lava, which most assuredly has undergone a state of igneous fluidity, and to which refrigeration has given an horizontal stratification. It may be objected, that granite forms chains of immense mountains, and that this is but a small current, scarcely a few yards thick; but the phenomenon is the same: the difference between great and little, however material with us, being nothing with nature.

Of Calastro.

" The same tendency to a basaltic conformation, which is noticed in the lava of La Scala, is observed again in the neighbouring current of Calastro. This, after passing through a defile below Vallelonga, spreads to a broad front on reaching the sea. What most deserves observation in the lava here, are the small crystallisations it presents, which seem to be the olivine of Wer-

Shocks.

Issue of lava.

symptom of an approaching eruption; but, towards nine in the evening of the last day, many symptoms were manifested. The houses about the mountain experienced violent shocks, which gradually increased in force; a very powerful one was felt at ten o'clock in Naples and its environs. At this instant, on the western base of the cone, at the spot called *La Pedamentina*, and from the midst of ancient torrents, a new mouth disgorged a stream of lava. This opening was 2375 feet in length, and 237 in breadth. Scarcely had the stream of lava begun to flow, before four conical hills, each having its small crater (the third alone excepted, which had two distinct mouths), arose out of the stream itself. From these different mouths stones were darted into the air with great noise, and in a state so highly ignited that they resembled real flames; the explosions indeed were so quickly repeated that they seemed but one, and formed a continued sheet of fire in the air, which received no other interruption than what was occasioned by the inferiority of the force of some of the ejections. They sometimes vomited substances, I may say, in a fluid state, for they expanded in the air like a soft paste, so that one may imagine they were either a part of the running lava, or masses of old lava fused and projected. Some of these terminated in the territory of Aniello Tirone, after having run the length of 1490 feet; the residue of the lava, pursuing its course, flowed upon Torre, presenting a front from twelve to fifteen hundred feet in breadth, and filling several deep ravines.

Destroys Torre del Greco.

"On reaching the first houses of the town the stream divided, according to the different slopes of the streets, and the degrees of opposition presented by the buildings. An idea may easily be formed of the accidents consequent on such a flood of fire; accidents which bear relation to the site of the manufactories, the thickness of their walls, and the manner in which they were assailed by the lava. Had not the mass of the stream suffered a diminution, from the different divergencies noticed, not a single house would have been left standing in Torre del Greco. The lava, after a serpentine course through the town, at length reached the sea-shore. The contact with the water diminished the speed of its course: still the current flowed into the sea in a body 1127 feet in breadth, and advanced into it a distance of 362 feet. Its entrance into the sea was not marked by any singular phenomenon; it began to issue from the volcano at ten at night, and reached the sea-shore by four in the morning; continuing a

Entrance into the sea.

tinual, and accompanied by a hollow noise, similar to that occasioned by a river falling into a subterranean cavern. The lava at the time of its being disgorged, from the impetuous and uninterrupted manner in which it was ejected, by striking against the walls of the vent, occasioned a continual oscillation of the mountain. Towards the middle of the night this vibratory motion ceased, and was succeeded by distinct and repeated shocks. The fluid mass, diminished in quantity, now pressed less violently against the walls of the aperture, and no longer issued in a continual and gushing stream, but only at intervals, when the interior fermentation elevated the boiling matter above the mouth. About four in the morning the shocks began to be less numerous, and the intervals between them rendered their force and duration more perceptible. One might compare them to the thunder heard in Italy during storms in summer, the loudest claps of which are succeeded by rumbling sounds which gradually die away.

"While I was making my observations on this grand eruption at the foot of Vesuvius, its summit was tranquil, and no phenomena were visible about its crater. I passed the night at sea, between Calastro and La Torre, to have a nearer view of this great operation of nature, these were the principal incidents of this horrible yet sublime scene. The ruins of Pompeia, buried beneath heaps of drosses and powders, did not certainly present a spectacle near so striking. To these objects, so powerfully calculated to fix the senses, was added another which forcibly touched the heart; this was a doleful group of fifteen thousand persons, bewailing the destruction of their city and property, who had had but a moment's notice to flee, and abandon their homes for ever; and were reduced to become wanderers, and dependent on the world for refuge.

Cloud of powders.

"About dawn the summit of Vesuvius ceased to be visible; it was covered with a thick cloud, frequently furrowed with lightning. This cloud gradually spread itself, and in a little time overshadowed the gulf, the city of Naples, and its vicinage. It was formed of a large quantity of that fine sand called *ashes*, and prevented all sight of the fire of the volcano. The sun, as it appeared above the horizon, presented a still more dismal picture. From the abundance of ashes in the air it seemed more pale than during the strongest eclipse, and a black scarf appeared to be spread over the whole of the gulf and the country. At the extremity of the horizon, towards the west, the day was more clear, while three branches: one proceeded towards Bosco, another towards Mauro, and the third to the plain of Mulara. The length of this current of lava was not less than an Italian mile; but as it flowed constantly over old lavas it did but little harm, merely laying waste and occupying a small extent of vineyard. From the spot where it diverged from its first direction it projected a small branch in a continued line: falling to this point over a very rapid slope, the speed with which it flowed must have been considerable; and a portion of its mass preserving its first impulse, naturally fell in this small stream, in which were four mouths in the shape of an inverted cone, the base of which is in the surface of the lava. This stream terminates in a small and regular hill, of a conical figure, on the summit of which are two mouths, in form of inverted cones. The dimensions of this second current are nearly half those of the first; consequently the mass of the whole is adequate to *2,804,440 cubic fathoms*. The coincidence and perfect resemblance of these two currents of lava sufficiently prove that they had but one common origin, and but one cauldron in which the matter was fused of which they are composed. How great then must be the recipient in which such an enormous mass could be contained!

Vast force required. And what powerful exertion of strength must have been required to break through the mountain in these two opposite directions! The lava, agitated by the expansion of elastic fluids, made its first effort to liberate itself on the eastern flank, and found a passage; but the resistance it met with from the mountain, no doubt occasioned its reflux, or rebound, against the opposite flank. The western current, taking its departure from a more elevated mouth, more quickly terminated its course; but the cauldron chiefly emptied itself by the eastern opening. The lava issued from it very slowly, compared with the celerity with which that flowed which proceeded from the eastern mouth, because it was no longer driven forward nor compressed by the total mass, which was already greatly diminished.

Attendant phenomena. On the morning of the 16th the lava ceased to flow over the western side, and the mouth of the volcano began to resume activity. The whole of its cone was covered with a very thick rain of ashes or powders, which totally hid it from sight, so that nothing could be distinguished on Vesuvius, which was wholly inaccessible. In this state it continued four days, during which many shocks of earthquakes were felt, and loud claps of thunder were heard. Thunder and lightning. Thunders raged in every part of the adjacent country, and the flashes of lightning by which they were accompanied, at intervals for an instant, allowed a view of the mountain, through the darkness in which it was involved by the rain of powders. This darkness was so prodigiously great, that at Caserta and other places, ten or twelve miles from Vesuvius, it was impossible to walk the streets at mid-day without torches, and that circumstance was renewed which is related by Pliny on the occasion of the eruption in the time of Titus, "*faces multæ, variaque lumina, solvebant obscuritatem.*" It is utterly impossible to determine with precision the quantity of ashes or powders that fell in the course of these days, as it was different in different places, according to the direction of the wind; it is however computed, on the base of observations at different places, that fourteen inches and six lines in depth fell on an area, the radius of which is three miles, the summit of Vesuvius being the centre.

Darkness.

"It would be erroneous to conclude that all this mass of matter proceeded from the entrails of the mountain; the greater part was the offspring of the ruins of the crater, which during these last days fell into the abyss below. A rain of ashes, when continued for any length of time, is very injurious to vegetation. Lands which, a few days before, presented the most smiling

Ruin of the crater.

Volcanic sand.

future to distinguish it by the name of *volcanic sand*, one which already begins to be common. On examining it with the microscope, this substance is seen to be composed of particles of a rough and earthy appearance, mingled with triturated fragments of felspar and augite. All are not alike, some being of large and others of smaller size. The grains are often of a dark grey colour, inclining to black; sometimes, and especially on the last days they fell, they were of a brighter ash-colour. It is constantly observed that, when the volcanic sand that falls is of a whitish colour, the eruption is near its end. This white colour of the volcanic sand may be derived from two causes; a greater trituration and tenuity, as in the instance of green glass, which when finely pulverised becomes white, or a longer exposure to the action of acid vapours. The sand ejected by the volcano, in the earlier stages of its eruption, issues from a furnace full of matter; but the vapours, as it begins to empty, have room to act with greater effect on the remaining substances. Some particles of this volcanic sand placed over fire effuse a perceptible smell of sulphur; others, lixiviated, yield a muriate of soda or ammoniac, or the sulphate of iron; and often two or even the whole of these salts are produced from the same sand. The vius in 1794 seemed as if about to engulf all nature; the earth shook; horrible roarings threatened the destruction of the country; a dark night overshadowed the land; ashes fell to a considerable depth; flames and smoke rose to an elevation seven times as great as that of the mountain, that is to say, to a twelfth part of the height of the atmosphere; vivid lightnings flashed in every direction, and the atmosphere denoted an abundance of negative electricity, never observed during the reign of tranquillity; torrents of rain committed dreadful ravages on the fruits of the industry of man; and every meteorological instrument underwent the greatest alteration, the barometer alone excepted; this, like the sage among worldlings, took no part in the confusion by which it was surrounded, but on the contrary seemed as steady as its partners were wavering, agitated, and unquiet. It required the most practised eye to distinguish throughout ten days, in which nature experienced the most dreadful convulsion, the slightest imaginable variation of this instrument.'

"At length the rain of volcanic sand having ceased on the 20th, and that which was spread through the atmosphere being dispersed, Vesuvius again became apparent; but its appearance with another, the immense quantities of stones, which struck against each other in the air; those which fell back into the cauldron, and those which from a prodigious height fell on the external walls of the volcano, produced a most frightful uproar.

Heavy rains.

"Such was the state of the volcano to the 5th of July; and during the whole interval another meteor occasioned incalculable damage to the fields in the neighbourhood of Vesuvius: this was rain, which for a fortnight was incessant, and mostly so violent that it laid waste the best grounds of Somma, Ottajano, and Bosco. Whenever a cloud appeared above the horizon, it seemed to be attracted by the volcano, and scarcely did it touch its summit ere immense streams were visible, precipitating themselves with horrible roaring to the base of the mountain. These impetuous torrents of water, mingled with volcanic powders, overturned the bridges, harrowed up the roads, tore up trees by the roots, and bore them along in their course, carried away houses, and utterly devastated the fields of one of the most rich and flourishing countries in the world. For the space of a fortnight its unfortunate inhabitants were in a state of uncertainty respecting their fate, and were repeatedly forced to abandon and flee from their dwellings, in the very dead of night, to preserve their few days, it neither injures the olive nor the pear-tree, which, in the midst of the general destruction, constantly retain their verdure and strength. This is a fact confirmed by all farmers, and which I have many times verified myself.

Gas.

" On examining this mephitic gas by the ordinary means, I found it to be composed of carbonic acid gas, azotic gas, and a portion of sulphuric acid, as is shewn by the precipitation of barytes, by the solution of muriate of barytes. The bad effect, therefore, of this gas on plants, is little matter for wonder, the deleterious nature of carbonic acid to the vegetable reign being known.

Lava of 1794.

" The colour of the lava of 1794 is a darkish grey, its hardness such as to yield sparks with steel, its grain coarse and earthy, its fracture irregular, its porousness various, for in some parts it is so compact as to resemble petrosilex in its grain; on moistening it, even by breathing, or on being wetted, it exhales an earthy smell: finally, it powerfully answers the magnet. Seldom is mica found in this lava in laminæ, but often in groups and small united masses; on these occasions it presents the same phenomena as in the lava of Granatello. The lava is rich in augite, which is frequently seen crystallised in may be regarded as fragments of a primitive rock, ejected without having undergone the action of volcanic fire*. Leucites are often conjoined with felspar and augite; and, like topaz, the earth of leucite may occur uncrystallised.

HYPONOME II. LAVA WITH CALCAREOUS SPAR.

Ferrara's account.

According to Ferrara, calcareous spar abounds in the ancient or rather primeval lavas of Sicily. Though the doctrine of infiltration begins to yield to that of contemporaneous sublimation by heat, yet his arguments in favour of the former have great weight; for when he afterwards mentions the zeolites found in the same basaltins, and the *analcimes* of Haüy, (which he proposes to call *cyclopites*, because they were first found in the rocks of the Cyclops, and appeared about the middle of last century in the cabinets of Prince Biscari, and of the Benedictine monastery,) he observes, that "this substance has not only infiltrated and crystalised in the most interior recesses of these enormous masses of the hard lava, but in a great quantity in the slits and in the middle of the marl, which forms a stratum above all these lavas; a convincing proof that its origin is posterior to the liquid state of the lava, and foreign to that sub-

Infiltrated.

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* Ibid. ii. 6.

ramids of three sides, joined at the centre, with diverging rays; their bases forming the surface of the circumference, but they are often covered with a spherical layer of the same substance, confusedly crystallised. Such are seen in the lavas of Murgo, between Simeto and Lentini; in the Rocks of the Cyclops; and I have found them, from four to six lines in diameter, in the vesicles of the lava which is scattered in fragments on the chalky mountain of Cifali, near Catania, where they form curious fans when gently broken.

" But more commonly this calcareous substance lines the cavities under the stalagmitic form, in the shape of hanging crystals, or implanted globules. I have beautiful specimens collected to the west of Lentini: some of the globules are void, the inner surface being only crystalised in what was formerly called the dogs-tooth spar, but now the *metastatic* of that diligent crystalographer Haüy. Under the same form these spars line the cavities of the beautiful tufo around Cape Passaro, formed of fragments of lava and limestone, and many masses of lava alone; and in the rocks of the Cyclops it is not only found in the cavities, but forming layers above the lava, and even above the stratum of marl which covers these famous rocks.

" This substance is still more frequent in the Others.

silky threads of unequal length, united in fasces, with diverging rays; but the chief singularity is, that all the mass is full of petrol, which also fills many of the cavities. On breaking this lava the oil runs out, which, though of a black colour, is so subtile as to approach naphtha, with a pungent smell, which it soon loses in the air. There seems no reason to doubt that this petrol has been produced by infiltration *."

HYPONOME III. INDURATED MUD WITH FELSPAR, SIDERITE, &c.

NOME VIII. VOLCANIC GLUTENITE.

This denomination includes, as usual, what are called bricias and pudding-stones, being fragments of different rocks joined by lava or tufo. The *peperino* of the Italians is a volcanic bricia; the cement being a grey pumaceous tufo, in which are concreted fragments of granite, felsite, marble, gypsum, with crystals of siderite and mica. In the extinct volcano of Beaulieu, three leagues to the N. W. of Aix in Provence, Saussure observed a singular pudding-stone, composed of fragments of vesicular

Peperino.

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* Ferrara, 179.

me instructive remarks and interesting singu-
rities: and the extreme minuteness of the de-
riptions will serve fully to instruct the reader
the nature of these complex substances, the
ingled products of fire and water*.

Catalogue by Faujas.

" *Division 1. Bricias, whose formation is*
ing to lavas, which in their state of fluidity
we embraced other kinds of lavas, whether com-
ct or porous, scorified, vitreous, or other stony
bstances reduced into fragments. When the
bstances thus imbedded present kernels more or
s angular of a certain size, and the lava which
ites them is hard and solid, they may be called
lcanic bricias. If, on the contrary, the frag-
nts are very small, and the paste which sur-
unds them is friable, soft, and rather earthy
an stony, the name tufo is more applicable.

From fire.

" 1. Volcanic bricia, formed of angular and
und fragments of black compact lava, of black
va rather porous, and some grains of white fel-
ar, strongly united by a very hard granular
va, of a reddish colour.

" 2. Bricia, formed of angular fragments of
ack lava, hard, with small pores, united in a

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* This is also from the *Annales du Muscum*. In the *Geologie,*
ginally delivered as a course of lectures, it is much abridged.

marble, of yellowish marble with a fine saline grain, which takes the polish; of grey stone of a very fine paste, which cannot be scratched by steel, but which nevertheless effervesces briskly with nitrous acid: it seems to be siliceo-calcareous. The different fragments of these stones are imbedded in a grey lava, rather earthy, but solid, mixed with many black pyroxenes, divided into very small fragments.

"7. Bricia, with fragments of white and grey marble, and some kernels formed of a mixture of clear felspar, and a black substance which has some resemblance to hornblende. Conglomerated nodules of black mica are also found in it. The several foreign bodies are imbedded in a grey lava, which contains in great abundance small fragments of pyroxene, of a brilliant black in appearance, but which, observed with a lens in a strong light, are found to be green: some strongly marked crystals of that substance are even distinguished, which are diaphanous and of a grass green, and some spangles of silvery mica.

"8. Bricia, with large nodules of volcanic chrysolite, of a greenish and yellowish colour, mixed with large fragments of porous lava, and of black compact lava almost scorified, cemented and of some geods with a crust of brown hematite, which seem to be the result of the infiltrations of a marl, which is found in pieces in this bricia, and which is strongly impregnated with iron.

"2. Bricia, formed of fragments of *brown porphyry*, and of *porphyry with a red base*, with parallelopiped crystals of white felspar, fragments of *white marble*, surrounded in their points of contact with black lineaments, which seem to be the result of an aqueous dissolution, which has intimately united all the parts which compose this singular bricia. The grey lava which forms its base, and which contains some grains of black melted pyroxene, is so amalgamated, by the assistance of calcareous infiltrations, with the other parts of the bricia, that the whole forms a substance capable of being polished.

Division 3. Bricias, or volcanic tufos, formed by ejections of substances reduced to pieces, to grains, or to powder, sometimes carried to a distance by explosions and by the winds, afterwards uniting, whether they fall into the sea, or are deposited in places where the rain water consolidates them, as at Pompeia, and elsewhere.

"1. Volcanic tufo, which owes its origin to showers of black and grey pumice, divided into From water.

well preserved as if they had lately been prepared. See what I have said of this curious variety of trass of the environs of Andernach, vol. i. p. 24, of the *Annales du Museum*. Spallanzani found a similar charcoal in a tufo of the isle of Lipari. See also vol. iii. p. 11, of Spallanzani's *Voyage to Sicily*.

"*Of the particular configuration peculiar to some tufos.*

"*Note.*—It must be observed, that under some circumstances tufos, particularly those which owe their origin to the concurrence of fire and water, have undergone a recession which has given them a prismatic form. I have seen similar ones, but in small quantities, in the extinct volcanos of Habischwald, near Hesse Cassel. The most remarkable of this kind are those of Campania, near the town of *St. Agatha*, also between Mounts *Sarchio* and *Vitolano*, near a place called *La Varrettella*: but the largest and the best formed are those which are found on the road to *Venafro*, near the bridge of *Calvi* and the tavern of Torricella.

Tufo in prisms.

"Chalcedonic substances are sometimes found in tufos, which seem to be the result of a secondary formation, such as those of *Pont-du-Chateau*,

Chalcedony.

intend shortly to make them public, by having them engraved, and to give the explanations of those which have relations with known species."

HYPONOME I. VOLCANIC BRICIA.

The various kinds are already mentioned.

Micronome 1. Peperino.
From the environs of Vesuvius, &c.*

Micronome 2. Leucite Lava.
From Vesuvius, Albano, &c.

NOME IX. SUBSTANCES EJECTED OR CHANGED.

Many kinds of rocks are at various periods ejected by volcanoes; often with some marks of fusion, but in many instances, exploded by the vapours, without being visibly affected by heat. Whole masses of rock, nay mountains, are also found changed by the action of the subterranean vapours, as the celebrated Puy-de-Dome, which, according to Saussure § 728, 729, is a porphyry with a base of earthy felspar; and he found one of the same kind in the Valorsine. Mont Dor

Puy-de-Dome.

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* *Monte Nuovo* near Naples, consists of indurated powder, pumice, and fragments of lava intermingled, forming a peperino.

also presents granite, evidently affected by heat, the felspar having become dull and shattered[*]. Several altered rocks are found in volcanic regions; and even the lavas sometimes become white, by the action of sulphuric vapours[†].

HYPONOME I. LIMESTONE.

This substance deserves the first place, as that ejected by Vesuvius is not only more frequent in cabinets than any other exploded rock, but contains several remarkable parasitic stones; such as 1. The *Vesuvian* of Werner, and *idocrase* of Hauy, the *jacint* of *Vesuvius* according to Saussure, the colour resembling that of a pale jacint. It is also found of an olive green, whence it is sometimes called *chrysolite* by the Neapolitan lapidaries. It would seem that the latter is, however, the same with the *olivine* of Werner, also called *volcanic chrysolite*[‡]. 2. The *sommite* of

Parasitic stones.

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[*] It is surprising that the French writers continue to spell *d'Or* as if it were the golden mountain, while Le Grand (*Voyage d'Auvergne* ii. 66.) has demonstrated, that the name was taken from the river Dor, which, with the Dogne, forms the Dordogne.

[†] The lava decomposes into clay, or rather the argil displays itself; whence the environs of volcanos are very fertile.

[‡] Because the olivine is found in basalt, the Wernerians reject it from the volcanic substances, while it is in fact the common volcanic chrysolite, as Breislak has shewn. Gioeni, p. 217, observes, that many scoriæ of Vesuvius and Etna contain a yellowish substance like glass, perfectly resembling that in the native iron of Siberia.

Karsten, the *nephiline* of Haüy, of a white or greenish grey, found in the ejected rocks of Mount Somma, which may be styled the parent of Vesuvius. Leucite is also found in the calcareous rocks of Somma, according to Breislak: but the *pyroxene* of Haüy, the *augite* of Werner, of a dark brown or green colour, rather belongs to granitic rocks.

Limestone, with volcanic jacint and chrysolite, from Vesuvius.

The same with leucite, from Monte Somma. Kirwan has strangely confounded the volcanic jacint, or vesuvian of Werner, with leucite or white garnet.

Limestone with sommite, from Monte Somma.

HYPONOME II. GRANITE.

In this substance the felspar, which, owing to the mixture of potash, is the most easily fusible, is sometimes either melted or shattered by the heat*. But the granitic lavas of Dolomieu, and other French writers, seem problematic. That patient observer says that he never saw them in such abundance, nor with such convincing proofs of having been fused, as at Sancta Fiora, on the confines of Tuscany and the Papal territories. If

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* In the language of jewellers *stunned*, corresponding with the French *etonné*.

HYPONOME VII. SANDSTONE.

This substance seems one of the rarest of the ejections; while, as it generally, if not always, accompanies coal, if the Wernerian theory of volcanoes were just, it would be among the most common.

This arrangement of volcanic substances being, from its nature, rather jejune, it may be proper somewhat to diversify it by a few general remarks, and some examples of singular volcanoes, chiefly from Patrin and other foreign authors, whose works have not been translated. It might have been thought unpardonable to have passed, with irreverent brevity, some of the grandest features of nature; especially as the recent progress of mineralogy has thrown new light on many topics; and the ignorance of the ancient accounts has been dispelled by the precision of modern science.

Patrin
theor

Patrin has started a singular idea concerning volcanic substances in general, which is, that they are *created* by gases; otherwise, in his opinion, it would be impossible to account for the vast quantity of matter ejected; and the volcanic mountains would, long since, have sunk into their own abysses. He introduces this new system by the theory of that great astronomer and geometrician Laplace, that *this earth, and the other planetary bodies, have been formed by the concretion of an aëriform fluid, which emanated from the sun.* The account, given by Dolomieu, of the singular *perpetual* volcano of Stromboli, furnishes our ingenious author with his chief arguments in favour of this hypothesis.

Stromboli. "The volcano of Stromboli is one of the most curious and important in the illustration of volcanic phenomena. It is in one of the isles of Eolus, on the north of Sicily; and Dolomieu's description is very interesting. This volcano was already noted in the days of Pliny; and its eruptions, from time immemorial, arise every eight minutes, so that it would seem that nature there displays every moment the concretion of gases into stoney matter, as a chemist shews it in his laboratory.

'The inflamed crater,' says Dolomieu, 'is in the north-west part of the isle, on the side of the mountain. I saw it dart, during the night, at regular intervals of seven or eight minutes, ignited stones, which rose to the height of more than a hundred feet, forming radii a little divergent, but of which the greater quantity fell back into the crater; while others rolled even to the sea. Each explosion was accompanied with a burst of red flame . . . . The stones ejected are of a lively red, and sparkle, having the effect of artificial fireworks.'

" I must here remark that these sparkling masses with the effect of fireworks, announce that their base is combustible.

" Having visited the mountain on the following day, Dolomieu thus continues his description.

' From a little summit, you have a view of the inflamed crater . . . . It is very small; I do not think that it exceeds fifty paces in diameter, having the form of a funnel terminating in a point. During all the time that I observed it, the eruptions succeeded with the same regularity as during the night . . . the stones ejected forming divergent rays; and the greater part, which fell back into the crater, rolling to the bottom seemed to obstruct the vent, which the vapours had opened at the moment of the explosion, and were thus again ejected by the subsequent eruption. They are thus tossed till they are broken and reduced to cinders (coarse powder). *But the volcano always affords a new supply; and is inexhaustible in this kind of production.* The approach of the eruption is not announced by any noise or dull murmur in the interior of the mountain; and it is always by surprise that one sees the stones darted into the

the electric fluid is a principal agent in volcanoes, because the eruptions are more frequent and violent in winter, and in stormy weather. He concludes that volcanoes, like springs, are emanations of fluids constantly reproduced.

Ferrara has simply observed that Stromboli ejects in a year, what a volcano, subject to violent eruptions, would explode in a day. He regards it merely as a volcano of an uncommon construction.

Isle of Bourbon.

A volcano in the isle of Bourbon sometimes rivals Stromboli in singularity, a *gerbe* or sheaf arising, like what is called a Chinese tree in artificial fireworks, and resembling tumultuous waves of fire, darted to the height of more than a hundred and twenty feet, and dashing against each other with a sanguine light, visible even at noonday. The summit presents glassy drosses; and the crater is lined with fragments of greyish lava much scorified*.

Submarine volcanoes.

The history of submarine volcanoes might be illustrated by the details which we have concerning the new isles which have appeared near Santorin, in the Grecian archipelago.

In his history of volcanoes, Ordinaire has given the following account of these phenomena.

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* Bory, Voy. 1804, 3 vols. 8vo. ii. 231.

very deep towards Santorin, where it covers the mountain, whence proceed incessant eruptions. There is no ground for anchoring near it, as is mentioned by M. de Bomare, vol. xv. page 128 of his Dictionary.

"Whatever on the surface of this sea-covered mountain be the quantity of matter which has issued from it, when the [illegible]es once set in motion in the void at its base w[illegible] become active, they rise violently and carr[illegible] the matter along with them, being always con[illegible]ed in their direction by the internal form of th[illegible]ountain. Its summit then, and the parts round its summit, are always the points most strongly attacked; there it must and does in fact give way, as is the case with a volcano on land opening for the first time. And when eruptions take place in a submarine volcano, the masses already settled are always affected by them, and partly open, and their surfaces either gain by the addition and adhesion of new ejections, or lose by some of their parts sinking into the fiery abyss, or into the sea. This is confirmed by all the eruptions, and particularly by the circumstances attending the last. They are to be found in all the periodical writings of that time. An account was published by Father Gorée, who was an eye-witness of it; and of his narrative I will give an

"In the year 726, the volcano, after violent ejections of ashes and red-hot rocks, disgorged a great quantity of lava, which joined Thia to Hiera.

"In 1457, this island was still farther increased, attended by the same circumstances. This event, and the date of it, are attested by an inscription on a marble stone erected near the gate of Fort Scarus, in Santorin.

"A sixth eruption, in 1570, produced a new island: it is called the Little Kamenoi.

"In 1650, the agitations of the volcano lasted almost a twelvemonth. Its greatest convulsions were at the beginning, from its opening on the 24th of September to the 9th of October. The sea rose to the height of forty-five feet, and that to such a distance, that some galleys of the Grand Seignor's were wrecked in the port of Candia, though it is more than eighty miles from Santorin. Smyrna and Constantinople were incommoded with the ashes which rushed out of the sea in whirlwinds of flame. All the particulars of this eruption are to be found in Kircher, a contemporary author, after the account of the preceding.

Eruptions of 1707.

"This inexhaustible volcano again opened in 1707. The Little Kamenoi was increased, and is now more than three leagues in circumference.

"Most of these eruptions, and all the circumgoing to examine it. Many parts of it were still burning. It was a shapeless mass of baked substances, amalgamated by a lava, which, Father Gorée says, appeared to the eye like the crumb of fine bread. But the very next day the inquirers were compelled to relinquish this hasty curiosity, and betake themselves to flight. They felt the new soil moving: it rose in some parts and sunk in others. The earth, sea, and sky, soon resumed their formidable appearance. The symptoms appeared even to spread wider and to threaten worse. The boiling sea several times changed colour: flames, following one another without intermission, issued as from a vast furnace, but accompanied with ashes and pumice. The frightful noise of subterranean thunders was heard. It seemed as if enormous rocks, darting from the bottom of the abyss, beat against the vaults above it, and were alternately repelled and thrown up again: the repetition of their blows was distinctly heard. Some of them, making or finding a passage, were seen flying up red-hot into the air, and again falling into the sea whence they had just been ejected. Masses were produced, held together for some days, and then disappeared. In this general disorder large portions of the Little Kamenoi were swallowed up. Meanwhile the labour of the volcano took a larger surface, its ejections became had the same origin, and yet the sea is here of such a depth as to be unfathomable by any sounding-line. These arose at different times; the first long before the commencement of the Christian æra, another in the first century, a third in the eighth, and a fourth in 1573. Another island arose in the year 1707 and 1708, between this island and *Great Cammeni.* The reader will not be displeased at seeing here a particular account of this extraordinary phenomenon.

Sant

"On the 23d of May 1707, after an earthquake that happened the night before, the last mentioned island was discovered early in the morning by some seamen, who, taking it for a wreck, rowed immediately toward it; but finding rocks and earth instead of the remains of a ship, hasted back, and spread the news of what they had seen in Santorini. How great soever the apprehensions of the inhabitants were at the first sight, their surprise soon abated; and in a few days, seeing no appearance of fire or smoke, some of them ventured to land on the new island. Their curiosity led them from rock to rock, where they found a kind of white stone that cut like bread, which it nearly resembled in its form, colour, and consistence. They also found many oysters sticking to the rocks; but while they were employed in gathering them, the island moved and shook

under their feet, upon which they ran with pred
pitation to their boats. With these motions an
tremblings the island increased, not only in heigh
but in length and breadth; yet sometimes while i
was raised and extended on one side, it sunk an
diminished on the other. Our author observed
rock to rise out of the sea, forty or fifty pace
from the island, which, having continued four days
sunk, and appeared no more; but several other
appeared and disappeared alternately, till at la
they remained fixed and unmoved. In the mea
time the colour of the surrounding sea wa
changed: at first it was of a light green, the
reddish, and afterwards of a pale yellow, accom
panied with a noisome stench, which spread itse
over part of Santorini.

"On the 16th of July the smoke first appeare
not indeed from the island, but from a ridge
black stones which suddenly rose about sixty pac
from it, where the depth of the sea was unfathom
able. Thus there were two separate islands, o
called the *White*, and the other the *Black Island*
from their different appearances. This thic
smoke was of a whitish colour, like that of
lime-kiln, and was carried by the wind to Santo
rini, where it penetrated the houses of the inha
bitants.

"In the night between the 19th and 20th o

July, flames began to issue with the smoke, to the great terror of the inhabitants of Santorini, especially those of the castle of Scaro, who were not above a mile and a half distant from the burning island, which now increased very fast; large rocks daily springing up, which sometimes added to its length, and sometimes to its breadth. The smoke also increased, and, there being no wind, it ascended so high as to be seen at Candia, and other distant islands. During the night it resembled a column of fire, fifteen or twenty feet high; and the sea was then covered with a scurf or froth, in some places reddish, and in others yellowish, from which proceeded such a stench, that the inhabitants throughout the whole island of Santorini burnt perfumes in their houses, and made fires in the streets to prevent infection. This, indeed, did not last above a day or two; for a strong gale of wind dispersed the froth, but drove the smoke upon the vineyards of Santorini, by which the grapes, in one night, were parched up and destroyed. This smoke also caused violent headaches, attended with retchings.

"On the 31st of July, the sea smoked and bubbled in two different places near the island, where the water formed a perfect circle, and looked like oil when ready to boil. This continued above a month, during which many fish were found dead might be as many more on the other side of the great volcano. On the 23d of August, in the morning, the island was much higher than the day before, and its breadth was increased by a chain of rocks sprung up in the night almost fifty feet above the water. The sea was also again covered with reddish froth, which always appeared when the island received any considerable additions, and occasioned an intolerable stench, till it was dispersed by the wind and the motion of the waves.

"On the 5th of September, the fire opened another vent at the extremity of the *Black Island*, from which it issued for several days, during which but little was discharged from the large furnace: and from this new passage the astonished spectators beheld the fire dart up three several times to a vast height, resembling so many prodigious sky-rockets of a glowing lively red. The following night the subterraneous fire made a terrible noise, and immediately after a thousand sheaves of fire blew up into the air, where, breaking and dispersing, they fell like a shower of stars upon the island, which appeared all in a blaze, presenting to the amazed spectators at once a most dreadful and beautiful illumination. To these natural fireworks succeeded a kind of meteor, which for some time hung over the castle of Scaro, which is seated on a high rock in the island of peared like a mountain, were seen and heard large pieces of rock, thrown up with as much noise and force as balls from the mouth of a cannon, which afterward fell upon the island, or into the sea. One of the small neighbouring islands was several times covered with these fiery stones, which, being thinly crusted over with sulphur, gave a bright light, and continued burning till that was consumed.

"On the 21st, after a dreadful clap of subterraneous thunder, very great lightnings ensued, and at the same instant the new island was so violently shaken, that part of the great furnace came tumbling down, and huge burning rocks were thrown to the distance of two miles and upward. This seemed to be the last effort of the volcano, and to have exhausted the combustible matter, as all was quiet for several days after. But on the 25th, the fire broke out again with still greater fury, and among the claps was one so terrible, that the churches of Santorini were soon filled with crowds of people, expecting every moment would be their last; and the castle and town of Scaro suffered such a shock, that the doors and windows of the houses flew open. The volcano continued to rage during the remaining part of the year; and in the month of January, 1708, the stones were thrown up all together into the air, and fell again into the sea at about two miles distance. From this time to the 23d of May, which might be called the anniversary of the birth of the new island, things continued much in the same state; but afterward the fire and smoke by degrees subsided, and the subterraneous thunders became less terrible.

"On the 15th of July, 1709, our author, accompanied by the Romish Bishop of Santorini, and some other ecclesiastics, hired a boat to take a near view of the island. They made directly toward it on that side where the sea did not bubble, but where it smoked very much. Being got into this vapour, they felt a close suffocating heat, and found the water very hot; upon which they directed their course toward a part of the island at the farthest distance from the large furnace. The fires, which still continued to burn, and the boiling of the sea, obliged them to take a great compass, and yet they felt the air about them very hot and sultry. Having encompassed the island, and surveyed it carefully from an adjacent one, they judged it to be two hundred feet above the sea, about a mile broad, and five miles in circumference; but not being thoroughly satisfied, they resolved to attempt to land, and accordingly thus raised by subterraneous fires, in the year 1720.

"This happened in the beginning of December, 1720. In the night, a violent earthquake was felt on the island of Tercera; and the next morning the top of a new island appeared, which ejected a huge column of smoke. The pilot of a ship, who attempted to approach it, sounded on one side of the new formed island, with a line of sixty fathoms, but could find no bottom. On the opposite side, the sea was deeply tinged with various colours, white, blue, and green, and was very shallow. This island was larger on its first appearance than at some distance of time after; and at length sunk in such a manner as to be now only just above the level of the sea.

"Upon this extraordinary production of nature, the narrator remarks as follows:

'What can be more surprising than to see fire not only break out of the bowels of the earth, but also to make itself a passage through the waters of the sea! What can be more extraordinary, or foreign to our common notions of things, than to see the bottom of the sea rise up into a mountain above the water, and become so firm an island as to be able to resist the violence of the greatest storms! I know that subterraneous fires, when tion, as not only appears from the testimony of Strabo before adduced, but from others. For Diodorus Siculus, who flourished at the beginning of the reign of Tiberius, says Vesuvius emitted fire in the time of Hercules; and he adds, that in fact it retained many vestiges of conflagration[*]. Vitruvius had before asserted that the eruptions of Vesuvius were mentioned in history, and that pumice, there found, also appeared near Etna, and in those hilly parts of Mysia which the Greeks called the burnt country[†]. Silius Italicus also expresses the same tradition. Nay, in latter times, Vesuvius became extinct from A. D. 1136 till 1506, that is 370 years; the crater being filled with coppice woods and pools of water, refuges of the most timid animals[‡].

From the month of October 1702, till July 1703, a series of earthquakes, like those of 1783, desolated the southern parts of Italy. Among other phenomena, a volcano near Sigillo, in Further Abruzzo, which had been extinct beyond all history or tradition, suddenly opened the cover of its crater, and smoke and flames issued for three days, after which it has remained tranquil. The mouth of the abyss is only about twenty-two feet

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[*] Lib. v. 21.

[†] Lib. ii. 6.

[‡] Acad. Nap. apud Ord. 237.

APPENDAGE TO THE VOLCANIC.

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FUMAVOLS,

OR

PSEUDO-VOLCANOES.

FUMAVOLS.

Products of Fumavols.

Dysert.

Cransac.

THESE trifling ignitions of coal-pits are treated by the Wernerians with an importance truly ludicrous. Their chief products seem to be indurated clay, and, according to some, tripoli. Slates may also be turned to slags; and what is called porcelain jasper, probably an iron stone affected by the heat, also appears in the vicinity of those ignited spots, particularly near Dysert in Fifeshire, where a coal-mine has continued in a state of deflagration, at least since the time of Buchanan, 1560; for he minutely describes the spot in one of his poems. Nay, according to Mr. Kirwan, who quotes the Memoirs of the Academy of Sciences for 1781, the mountain of Cransac has continued burning since the year 1400.

It is observable, that Mr. Kirwan, and the other Neptunians, regard columnar argillaceous iron ore, which has a singular affinity with prismatic basaltin, as a product of these pseudo-volcanoes, a name which would more properly be-of Cransac is mentioned in charters, as burning in the year 1400; and has been noted in several works of geography. The smoke may sometimes be seen at the distance of a league; and at night, especially during rain or snow, the flame appears red, yellow, or blue.

M. Morand has given a curious list of the substances affected by fire, being chiefly indurated clay, or porcelain jasper; slate of a brick red, often with impressions of vegetables as usual in coal-mines; dross from oxyds of iron; the dead rock of the Germans, or red sand-stone; slate reduced to impalpable powder; a kind of tufo composed of powder and sand; besides sulphur, alum, and ammoniac.

His account of the hill of Fontaynes, where the coal-mines took fire about the year 1763, is curious, and may give the reader a complete idea of a fumavol or volcanello in its greatest activity.

Hill of Fontaynes.

"The hill of Fontaynes, situated near Cahuac, is surmounted by two adjacent houses, forming the hamlet of Fontaynes, in the parish of Albin; the lower house belongs to *Muratels*, and the upper to a person named *Capelle*, proprietor of the mountain. The fire having destroyed his plantation of chesnuts; and his coal-mine, which was of the first quality; now threatlours of these fragments belong to those which are known to be the result of calcination, more or less acting on earths and argillaceous or schistose rocks, especially of a ferruginous nature. This dry and disordered surface presents, particularly towards the eastern side, against which the smoke is oftenest driven, the most unequivocal characters of the completest sterility, no kind of plant being to be found there, not the least verdure.

Desolate.

"Covered twelve years ago, as well as all the neighbouring quarter, with magnificent chesnut walks of the first quality, a second resource for the country after coal, there remains no longer any trace of these trees, except on the lower borders of the mountain, even in the part which is inflamed; where is perceived, nearly opposite Capelle's house, a single stump, still adhering to a portion of the trunk above ground. This stump and the trunk, hollowed and mined by the subterranean heat, are, actually, only a mishapen mass, which, seen from the house, is distinguished by its coal-black colour, and the smoke which issues from it, as from a vent spouting from the earth.

Smoke.

"From all points of the surface of this mountain, even from those where neither crevice nor dislocation is perceived, through ashes, earths, "In order to furnish myself with an exact and complete picture of all the parts of this phenomenon, which had drawn me thither, the circumstances I have just related were the only ones, to which I confined my first inspection. For that purpose, I remained for some time at the place where I arrived coming from Albin; it was directly on the crest of the mountain, above its inflamed part, bordering even on the brink of the soil where its degradation is at present marked. What there most astonished me was, three kinds of luminous globes (I describe them as they appeared to me), at different distances from one another, in the lower part of the mountain, nearly of the same size as the moon appears when at the full, of a bright red, or such as the fire in a forge appears, at the farther end of a smithy when seen from a clear and distant place.

Fire.

"I did not know what it was; I nevertheless attentively observed these brilliant points, which I was desired to consider. Do you see the fire? said they. The stones, or any thing found at hand, which my guide, and those who were with us at the time, amused themselves with throwing towards the place where I perceived these bodies of light, explained to me, what I had neither been able to judge of nor define: they were so many apertures, which served as chimneys to the number of little crevices, rather indented, which extend, in a serpentine direction, to a greater or less distance. These little crevices are themselves distinguished by a constant trembling, perceptible on their edges; the playing of the flame, joined to the continual derangement of the edges of the crevices, which falls in a fine powder in the interior of the clefts, giving them a particular motion, which cannot be better compared than to a kind of twinkling.

Crevices.

"In other parts the fire, confined in a kind of open ravines which are very numerous, struggles against the wind, when it blows in the direction of those trenches; and forms, to the sight, a real stream of flame.

"By sounding the earth with my cane, to avoid those places which were too hot, and regulating my steps by the wind, so that the smoke and suffocating exhalations of hot, humid, and sulphureous vapours, were driven before me, I had the satisfaction of approaching and examining at my ease, among others, a very large crevice, which, at that time, happened to be burning; its winding, broad, and elongated mouth, was as if enamelled on its exterior edges, by volatilisations of different colours, and of the greatest delicacy, which from time to time fell into the fire.

"On the kind of ashes which formed the soil of this object, of diversifying it, of changing the action of the fire, by throwing different things into the precipice, which sometimes seemed lost in an instant, afforded a kind of amusement, not unworthy a naturalist. Stones thrown bounding into this furnace, produced flaming eruptions with sparkling, even with a detonation, and created as it were little tempests, which gave a kind of diversion, which might be renewed as often as the shock repeated in the chambers of fire had neither destroyed nor overwhelmed them. If it was possible to approach these furnaces with safety, and without danger throw in large masses of any substance whatever, so as suddenly to compress the fire within, there is no doubt, but one would see a real brisk explosion[*].

"The singularity of the sight, of which I have endeavoured to give a sketch, would completely satisfy the most indifferent traveller; it still burning in certain places. These ashes, if they may be called so, heaped sometimes in sinking hollows, form very dangerous spots; a stick may be thrust into them with the greatest ease; in going over them, one may sink to one's knees: I myself found, that, besides the great heat which is concentrated in them, it was no little trouble to get out of them.

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[*] "That related by M. l'abbé Marie, probably had no other cause than the detachment of a considerable part of the earth within. M. Laurens, curate of Albin, informed me, that in September last, this mountain in the night had made a considerable explosion. The noise which accompanied it, was like that of a cannon, the ground of the vicinity, to a considerable distance, was next morning found covered with stones thrown up by this eruption; the quantity was observed, and was estimated at 200 cart loads. The surface of the hill also showed by its alteration, the conflict within; all which was caused by a current of water, which had been injudiciously introduced, with a view to extinguish the burning of the mountain."

"The liveliness with which the fire shows itself, towards the east and the south of the hill, where the trees split at 30 fathoms' distance, does not permit much detailed observation, otherwise than as relates, either to the fiery spectacle of a considerable surface of earth, or to the aspect of a confused and extraordinary subversion. One cannot approach every spot one would wish. In some, at the bottom of the burning part, the heat is sufferable; the neighbouring inhabitants roast their chesnuts in it; even rabbits like to burrow in it, and, although the season when I was there was extremely hot, I have seen some of those animals driven from places contiguous to the burning soil. On approaching the centre of the mountain, the superficial heat becomes stronger; besides, this burning and moving earth, in some places, will not allow you to remain any time; either the stones give way under the feet, and are buried in the ashes which they cover; or the

SUPPLEMENT.

VEINSTONES.

VEINSTONES.

Name.

THESE stones have, in cabinets, been often confounded with rocks, from which they should in general be carefully distinguished. They are called veinstones, because they are found in the veins, either metallic or barren, which traverse many mountains.

The reader who desires complete information concerning those veins, one of the most important topics in the science, is referred to the elaborate work of Werner*. A few general ideas will be sufficient for the present design.

Werner's account.

Most mountains consist of stratified rocks, by the Germans called *flœtze;* and the beds are often intersected, almost at right angles, by what are called *veins*, of more or less length, depth, and thickness; sometimes metallic, and sometimes of a rocky substance; but dissimilar from other parts of the mountain. Oppel, formerly president of many has been supposed to extend to Potosi, that is 840 geographical miles. The grand vein is always nine feet in thickness; but on both sides numerous veins branch off, which may be said to penetrate in all directions a chain of mountains 30 miles in breadth*. From this surprising example, an idea may be formed of the extent of some veins, which have continued to be richly productive after the labours of many centuries.

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* Nouvelle Theorie de la formation des Filons. Traduite par Daubuisson. Paris, 1802, 8vo.

Mines.

In conducting their subterranean operations, the miners use a kind of compass, divided into twice twelve hours; 12 and 12 being N. and S. while 6 and 6 are E. and W.† This is used to estimate the *direction* of the vein; while its *inclination* is measured by the plummet. The *dip* is often confounded with the inclination, but seems more properly to imply the general declination, taken in the line or direction of the vein, than the lateral inclination or obliquity. Thus if a book be held obliquely, the back will show the direction of the vein, which is seldom strictly horizontal, but dips at one extremity, while at the other it is salient; or, in the language of miners, *bassets out*, or *rises to the day*. The width of the back shows crystals, which, when enlightened by torches, exceed all the ideas of oriental magnificence, and seem the chosen abodes of the fairies of the mine; a race whose existence was anciently credited in all mineral countries.

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* Molina, Ist. Nat. del Chili.

† Invented by the Germans, the fathers of modern mineralogy. The silver mines in the Hartz were discovered A. D. 968. Those of Saxony, by a Hartz miner, about A. D. 1180.

These cavities are often found where the vein is most powerful, and the sides are covered with depositions of various periods, whence Werner adduces them in support of his theory, that the veins were once empty, and were filled from above; especially as the crystals are covered on that side with little crystals of pyrites, magnetic iron, and galena, which, by his doctrine, may have distilled from above. This is opposed by the theory of Trebra, who for thirty years superintended the mines of the Hartz, and who affirms that metallic veins are formed by the fermentation and exaltation of vapours, which we now call gases; and which operate as it were a kind of life in the interior of the earth, perpetually decomposing and transmuting mineral substances*. He would perhaps have inferred that, though the gases rose from beneath, they were congealed, as in distillery, by the superior cold, and then let fall their depositions. Veins sometimes cross each other in different directions; and it seems clear that those

Trebra's idea.

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* See his curious work on the Interior of Mountains, a folio volume translated into French, by Dietrich.

others are divided from the rock by the salband, or by the besteg of clay. The ore passing into the chinks of the rock, sometimes for a few inches, never more than a yard, is always in a leafy or superficial form. In different mining districts of Germany, several silver ores are wrought in the decomposed gneiss of the rock adjacent to the salbands of the mine; and at Kongsberg in Norway, native silver appears in gneiss, mica-slate, and hornblende. Copper, galena, and even tin, sometimes assume the same appearance.

Sometimes fragments of the rock have dropped into the vein, and been enveloped in its substance. But Werner seems to elude a great difficulty, the similar appearance of masses of mineral, by the French called *poches* or pockets, which have been accidentally discovered at detached and wide intervals, in the solid body of the rock.

Stone veins.

It must not be conceived that all veins are metalliferous. Many, on the contrary, disappoint the hopes of the miner, and are found to consist entirely of stone. Werner mentions veins of granite, porphyry, limestone, basalt, wacken, and grunstein. He adds, that in some parts of Saxony veins are found of small-grained granite, in a rock of mica-slate, and these veins are traversed and deranged by veins of silver, which proves that the granitic veins are more ancient. In other districts thickness, traversing diametrically the mass of the rock."*

It appears, from the conclusion, that the Pic du Midi, the chief object of these observations, is entirely composed of primitive rocks, in distinct and continued beds, or properly arrects, inclined from 60 to 80°; the superior beds, immediately covering the limestone, being gneiss and garnet-rock; above which are numerous alternating beds or arrects of limestone, trap, and sometimes of granite. The disposition of the trap is remarkable, as it often affects, between two level beds of limestone, folds either single or multiplied, and of the strangest appearance. The granite of the superior beds or arrects presents many features, as a vein, as a bed, and as a constituent part of many calcareous rocks; but, in the latter case, it is only found on the surface, as if it had been deposited soon after the compaction of the calcareous molecules.

Veins of granite, composed of quartz, felspar, and white mica, have also been observed by Besson, in the Limosin, in a clay slate. They are on a plain which has been tilled; and he observed no granitic rock in the neighbourhood. This granite is in very large and irregular grains; a circumis a compound mineral concretion of various colours, appearances, and degrees of hardness, and not unfrequently of various colours in the same mass, though white often prevails. This compounded stony concretion is called by miners a *rider*, perhaps from its riding the vein, or separating it longitudinally into two or more divisions. This mineral stone is hard and heavy, sometimes compact and solid, but frequently cracked and cavernous, rising in irregular and mishapen masses, and generally exceeding hard. A rider frequently contains a variety of different substances or species, as well as different colours, in the same mass, such as spar, quartz, fragments of the rocks near the vein, sometimes pyrites, and often ore in grains and flowers, and sometimes different ores, as lead, copper, &c. in the same mass, and all these strongly coagulated or concreted together by a whitish or a brownish-white substance, resembling quartz and agate, which seems to have enveloped the several articles in the composition when the whole was in a fluid state. I call this veinstone, as I think the term should be the most intelligible to naturalists, it being always found in veins, upon the superficies of them, and in fragments and masses lying about upon the face of the ground, which have slidden, or been forced off, the superficies of veins. But the veinstone does not always contain so great bole; a red unctuous ferruginous clay; with other kinds and colours, especially that called *gur* by the Germans, of various tints of brown, and resembling rappee, and sometimes Spanish snuff. The *peach* of the Cornish miners, chlorite, or green bole, is also frequent.

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* Jour. des Mines, iv. 751. 761.

Gur.

Rider.

From the account which Williams gives of the *rider*, in the very imperfect mineralogical language of that period, it would appear that he means to indicate a vein of ferruginous quartz, generally found to accompany metallic ores. By his description it is very rough and irregular, and full of little cavities, containing a ferruginous powder like snuff. The whitest parts have some resemblance to what is called a *bur-stone*, chiefly used for mill-stones, their irregular surface serving the purpose of trituration: but the rider generally contains heterogenous substances, as ores, pyrites, spar, fluor, &c.[*] It seems often to approach keralite, or the hornstein of the Germans, which sometimes even forms mountains, replete with silver and other ores.

It would seem that the cavities containing druses of small crystals, chiefly occur in the purer portions of the rock; and his account of this beautiful kind of veinstones merits transcription.

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[*] Will. i. 379.

ore, pyrites, and spar, shot also into prismatical, cubic, and other figures; and besides these, clusters of grotesque figures which grow out of one another, and are as it were piled upon one another. The whole inside of the cavern is sometimes most magnificently adorned with the most wildly grotesque figures, which grow upon and branch out of one another, in a manner not to be described; and with all the gay and splendid colours of polished gold, of the rainbow, and of the peacock's tail, and all these blended together, and the masses reflecting all the beauty of such an assemblage of gaudy colours. But it may be remarked, that these caverns are never so magnificent and glorious but when there is less or more of yellow copper ore, or of the pyrites in them: as these ores are found to produce, in hard veins, the most beautiful colours in the world. An eminent instance, in proof of this assertion, is to be seen in the copper veins in the parish of Colvend, in Galloway.

"These mineral loughs, or caverns, are the great source of materials for grotto work; and the specimens collected from the mines are generally the most showy dazzling articles in the whole arrangement of the splendid grotto."*

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* Will. i. 288.

are remarkable, when they have attained several inches of length, by their extreme flexibility, while calcareous stalactites are broken with the slightest effort*. In his account of his own cabinet, Trebra mentions that, in 1782, a peasant digging his garden in the village of Seppenrode, dependent on the bishopric of Munster, found a grey flint, about nine inches in length by four in breadth, having nothing particular in its exterior appearance; but having broke it for his tinder-box, he found within a cylindrical cavity, containing twenty little pieces of silver, which appeared to have been tied with a thread, of which some vestiges were apparent. The cavity was exactly moulded on this little pile of coins, and the inside was black; but the most surprising circumstance is, that the most ancient of these coins are only of the sixteenth century. Trebra's cabinet contained a piece of this flint, and one of the coins presented to him by Prince Gallitzin, with an authentic certificate of the circumstances above-mentioned†. Mr. Kirwan has another example of coins found in flint‡.

In his large work on the interior of mountains, modern; appatite and some fluors being the oldest of this description. Barytes seems one of the newest substances which appear in veins. Quartz, if not the most ancient, appears to be of all ages; while wacken and basalt seem to be recent. Trebra has observed, that certain gangarts seem more generally to be found in certain kinds of rock. Quartz and barytes are more frequently found in granite, than calcareous spar. Porphyry also contains much quartz, little barytes, still less calcareous spar, and almost never fluor; but there are gangarts of chalcedony and jasper, which are seldom found in granite and gneiss. In argillaceous mountains the prevailing gangart is calcareous spar, while barytes and quartz are rare. In calcareous mountains quartz seldom occurs, while calcareous spar, barytes, and fluor, are abundant.

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* Journ. des Mines, No. 23, p. 76.

† Ibid. p. 75.

‡ Geol. Ess. 447, where he briefly quotes Schneider, Top. Min. 114, for 126 silver coins found in flints at Grinoc in Denmark, and an iron nail at Potsdam.

In the mines of Giromagny, in Alsace, the chief gangarts are quartz, trap, fluor; the rock being almost universally what was called petrosilex, more probably hornstein than felsite. The *direction* of the veins is very various; and those that are north and south sometimes have their *inclination* to the east, sometimes to the west*. Among veinstones must also be reckoned bricias, composed of fragments of the mass of the veins, pebbles, of various sizes, either round or oblong; the greatest number being of quartz, like those found on the shores of the sea, and in the beds of rivers; while the intervals are filled with a white earth, sometimes ochry. The works are 500 feet under the mountain, and the inclination of the vein is from 60 to 70 degrees. Duhamel adds, that the disposition of the vein admits no doubt that it has been formed after the banks of pebbles, which serve it as walls: and that it may be inferred that the two banks of pebbles were at first united, and afterwards rent and filled with this vein. But may it not be simply a pudding-stone, of which the cement is decomposed, a common effect of metallic veins*? Nor is it wholly inconceivable that the vast receptacle of subterranean waters, known to exist in many parts of the globe, may contain extensive beds of pebbles, which may be forced into any cavities by the prodigious power of earthquakes, or other phenomena, occasioned by the extreme force of steam, vapours, and gases.

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* See the table, Journ. des Mines, iv. 291.

Petrifactions.

Among the most remarkable veinstones must also be classed petrifactions, which have unex-

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* Daub. Theorie de Werner, 83. Near Greenock in Scotland, ore is found in pudding-stone. Will. i. 358.

Werner has informed us that, in many veins, the rock on both sides, or, in the miners' language, the *roof* and the *sole*, the *hanger* and the *leger*, is altered and decomposed. This accident chiefly takes place in mountains of granitel, gneiss, mica slate, common slate, and porphyry. But this decomposition seldom extends to more than one of the constituent elements of the rock; for the quartz remains entire; while commonly the felspar, often the mica, and very often the hornblende, are decayed; the potash of the one, and the iron of the others, being very liable to decomposition. This alteration sometimes extends a considerable way, even a fathom; and is not always apparent along the vein, but chiefly in those parts where the mineral abounds with sulphur. In the pursuit of a barren vein, when this decomposition begins to appear, it may be concluded that ore is not far distant.

This change Werner ascribes to acids in the dissolution that formed the vein; and supposes that the felspar is changed into kaolin, or white clay, by the carbonic acid; and he gives examples of gneiss and granite thus decomposed. He also supposes that the sulphuric acid may affect the mica and hornblende, and convert them into that green bole or lithomarga, which was originally tric layers. For these circumstances I shall thus account. The granitic rock being divided into masses by horizontal and vertical fissures, as most granites are, the decomposition arising from the atmosphere would first affect the angles and sides, and reduce them into that kind of gravel of which we have spoken, while the masses of course assume the form of balls. The decomposition, afterwards penetrating gradually into their interior, would successively relax the tissue, and thus form concentric layers; while the inmost part would continue to preserve its solidity, thus forming the kernel. One of the effects of the decomposition has been the oxydation of the iron in the felspar, whence the red colour of the gravel, of the concentric layers, and all the decayed parts; while, in the kernel, the felspar is of a very fresh bluish white. This oxydation of iron, by the common influence of the atmosphere, is the cause of several appearances in rocks, particularly the sandstones. In one of the balls, which was on the surface of the earth, the upper hemisphere of layers was entirely wanting, the fresh and solid kernel being displayed; while beneath it was enveloped by the lower hemisphere of decomposed layers, the upper having been carried away by the winds, rains, and other meteoric influences. I report this fact original situation; and that under this pretended gravel would be found the solid rock.

"I shall not here enlarge on the destructive power of the elements, but reserve the subject for another work; where I shall show, by a series of facts, its consequences in granites, sandstones, basalts, and almost all the rocks. I shall show that acting constantly, and without interruption, during a long series of ages, it must have produced very great effects on the solid crust of our globe; and has strongly concurred in fashioning the inequalities, now observed on its surface. I shall with regret be obliged to combat the opinion of Dolomieu; the vivacity of whose imagination could not bear the slow and uniform progress, which experience shows to be that of nature. He said he could not believe that a rivulet should have scooped out large valleys: but I must observe that nature has time entirely at her disposition; and that a finite effect, produced an infinite number of times, is an effect infinitely great."

It is hoped that these observations will be sufficient to direct the student of nature in his attention to veinstones, which, whether in mountains or in cabinets, have often been confounded with rocks. In the latter, particularly, they have sometimes led mineralogists, and even geologists, to

APPENDIX.

APPENDIX.

No. I. *On the ancient Manner of carving Granite.*

ZOEGA, p. 189, et seq.

[See the translation, Vol. I. p. 199.]

RELIQUUM est dicere . . . . de Barberino obelisco. Nempe ad eum scalpendum instrumenta quædam adhibita videntur quorum in magnis Obeliscis nullum deprehenditur vestigium. Quæ enim lineæ sunt rectæ, vel ad circuli segmentum curvatæ, non acuté incisæ sunt, neque profunditatem habent equalem: sed fundus concavus est; ipsi sulci in mediâ suâ parte profundiores, ad extremitates sensim extenuantur, donec paulatim evanescant. Nec desinunt puncto definito in eo loco, qui terminus est rei quam representandam sibi sumserat sculptor, sed exilior pars procurrit extra limites figuræ.

Unde clarum fit ejusmodi sulcos non factos esse stylo nec smyride laminâ cultriformi subactâ, sed serra aliquâ lunatâ, cui subjiciebatur smyris, et alterno motu incidebantur sulci. Sed in rectis lineis; ubi vero curvæ essent, serrâ etiam opus erat curvâ. Quoniam vero figuræ incavita te eminentes turgidiores sunt, et singulæ partes aliqua deformantur globositate, probabile fit eas teretro vel tubo formatas esse smyridis subsidio, licet ejus instrumenti vestigia non appareant, figurarum superficie fricando expolita . . . . .

Universim in hujus classis operibus tempus lucrifacere studuerunt artifices; et serris, tuctris, atque frictione efficere,

Pentelican.

Mylassian.

Proconnesian. Tomb of Mausolus. *Vitruv.*

Thasian.

Coralian from the river Coralius in Phrygia; also called Sangarion, from the river Sangarus; resembling ivory.

Phoenician, Tyrian, or Sidonian, from Libanus; used in the Temple of Solomon. *Josephus.*

Arabian. Diodorus says, that in weight and whiteness it exceeded the Parian.

Lesbian, greyish white (Palombino); also dark grey.

Conchites, white with shells.

BLACK. From *Tænarus* in Laconia.

> "Quidve domus prodest Phrygiis innixa columnis,
> Taenare sive tuis, sive Caryste tuis."
>
> *Tibull.*

> "Quod non Taenariis domus est mihi fulta columnis."
>
> *Propert.*

The green was from Mount Taygetus. The Crocian was probably white, as statues were formed of it.

Lydian. (Basanite.)*

GREEN. Of Mount Taygetus in *Laconia,* which extends through that country to Arcadia: *(verde antico.)*

> "Illic Taygeti virent metalla."
>
> *Mart.*

> "Et quod virenti fonte lavit Eurotas."
>
> *Id.*

> "............Heic dura Laconum
> Saxa virent."
>
> *Sidon. Ap.*

---

* The stone of Alabanda in Caria, black inclining to purple, was melted and used for glass (Pliny), so could not be a marble.

2 Q 2

yield a certain soft stone, which was wont to be drawn into a fine thread; for I suppose some here have seen towels, network, and quoifs woven of that thread which could not be burnt; but when they were soiled with using, people flung them into the fire, and took them thence white and clean, the fire only purifying them. But all this is vanished, and there is nothing but some few fibres, or hairy threads, lying up and down scatteringly in the grain of the stones, to be seen now in the quarry."*

Atracian, from Atrax, a town on the river Peneus, not far from the celebrated vale of Tempe, in Thessaly, whence it was also called *Thessalium*.

The ancients included all the rocks used in sculpture or architecture under the name of marbles; but the *verde antico*, which is really a serpentine marble, is mentioned by so many ancient writers as the most cheerful of all, with veins of a grassy appearance winding in a spiral manner, and presenting white parts when polished, that no reasonable doubt can be entertained of its being the Laconian sort.

Paul Silentiarius, in the sixth century, wrote a poem, in which he describes the decorations of the famous church of St. Sophia, then erected by the Emperor Justinian at Constantinople. The subject led him to a minute description of the most celebrated ancient marbles; and that of the Atracian, contained in six lines, may be thus literally translated. "Whatever the Atracian land produces in the plains, not in the high mountains as the other rocks, in some parts of a light green not far from the colour of the emerald, in others proceeding to a deep and full green. There is also something like snow added to a black splendour; all which concur to form one beautiful whole." From other passages of ancient writers, it appears that this stone is described in the mass, as being of a leek green; whereas the Laconian is mentioned as

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* Plutarch's Moral Treatises, iv. 54. Tournefort, Travels, i. 176, mentions amianthus from Carystus, as being now an inferior kind, imposed on the ignorant as plumose alum.

(Maurasius or Aurasius). It was also found spotted with red and white *(Africano fiorito. Rezziato.)*[*]

> " Sola nitet flavis Nomadum decisa metallis
> Purpura."
>
> *Stat.*

> " Heic Nomadum lucent flaventia saxa."
>
> *Id.*

> " Nomadum lapis additur istis,
> Antiquum mentitus ebur."
>
> *Sid. Apoll.*

Precisely the *Giallo antico.*

BLUISH GREY OR TURQUIN. This, as well as the pure white, was found at Luna. Strabo. *(Bigio.)*

VARIEGATED. *Phrygian* from Synnada, the *Phrygius lapis* of the classics; white, with red veins and spots.

> " . . . . ubi marmore picto
> Candida purpureo distinguitur area gyro."
>
> *Stat.*

> " Purpura sola, cavo Phrygiæ quod Synnados antro,
> Ipse cruentavit maculis lucentibus Atys."
>
> *Stat.*

The spots either rose colour or deep red *(Fiore di Persico, Cipolazzo, Cotonello, Porta santa*[†]*.)*

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[*] The *Giallo Annulato* or ringed marble may be alluded to by Pliny, xxxv. 1. when he speaks of egg figures being artificially inserted.

What is called African Brecia is quite common even in England, and is quarried at Saravezza in Tuscany, presenting large pieces of brown, reddish, and white, on a black ground. There is no ancient authority for its being African. One kind, however, resembling the *Fiore di Persico*, Brard, 348, rightly conceives to be from the same quarries, that is, Synnadic or Phrygian.

[†] Specimens of two inches of course vary much. Larger pieces would better determine the kinds. *Antica*, like *Oriental* in gems, sometimes only implies a beautiful marble.

Thebais. Paul Sil. says it was brought down the Nile in large vessels.

Some have inferred the word *basalt* to be of Hebrew origin, as in that language *barsalt* or *barzalt* implies *iron*. Bellon, *It. Eg.* says he saw a pyramid of basalt as hard as iron.

Ptolemy, iv. 5, says that the eastern part of Egypt, on the Arabian gulf, was possessed by the Arabs; and among them were the quarries of *lapis Troicus*, alabastrine, porphyry, *black stone* (basalt), and of basanite. Herodotus, also, ii. 8, mentions the quarries in the Arabian chain. The town of *Alabastron* was so called from its alabaster; and *Porphyrio* from its porphyry. See Garof. 32.

No. III. *The value at Rome of Specimens of ancient Stones**.

Valore di Marmi, Alabastri, Pietre tenere e dure, ragguagliato al palmo cubico Romano.

Marmi e pietre tenere.

	Sc.	baj.
Marmo bianco di Carrara, il palmo	,,	70
Greco	,,	90
nero di Carrara	2	,,
antico, detto vulgarmente di paragone	8	,,
giallo di Siena	2	50
detto Porta Santa, antico	5	,,
detto fior de persico antico	14	,,
detto Settebase semplice antico	2	,,
a rose antico	8	,,
giallo antico	7	,,
in massa grande	8	,,

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* Petrini Gabinetto del Collegio Nazareno, tom. ii. App. Tavola xi. The Roman palm is about nine inches. The *scudo* (which contains one hundred *bajocci*) is about 4s. 6d.

	Sc.	baj.
Granito rosato	6	„
steatitico, detto volgarmente Granitone, bianco e verde	6	„
Granitello	„	50
Basalte nero d'Egitto	10	„
Orientale verde	20	„
Verde di Memfi, volgarmente detto Serpentino antico	3	„
Breccia d'Egitto di fondo verdino	8	„

I soprammentovati prezzi si aumentano, non solo in proporzione della mole, ma anche della bellezza della pietra o marmo. Cosi, per esempio, il marmo detto Porta Santa se abbia colorito piu acceso; il verde antico se sia de macchie bianche e di verde pieno ben rilevate; e il granito porfiritico se sia di color di porpora vivo, con grani di felspato bianco romboidale; avranno sempre pregio maggiore.

No. IV. *Account of the Hill of St. Gilles, near Liege.*

Lametherie (Theorie, v. 71) has described the hill of St. Gilles, near Liege, adjacent to the river Meuse (which is seen on the left, with the coal passing under it) from Genetté: as in the plate here reduced, Dom. VI.

The height of the hill is 3200 feet; and it contains sixty-one beds of coal, separated by other beds. Many of these beds of coal and intermediate substances are composed of smaller beds; and, without doubt, the lowest beds of coal have not been discovered.

The beds of the chief hill form a concave curve; but after passing under the Meuse, they become horizontal under the little hill on the left. They afterwards rise, and become almost vertical.

On the other side, or right hand of the print, they are bent like chevrons; while the intermediate beds assume the like form.

7. *Intermediate* 56 *f. again.*
Seventh bed 2 f. 3 i.
8. *Intermediate* 21 *f.*
Eighth bed 4 f. 2 i. In three layers.
9. *Intermediate* 28 *f.*
Ninth bed 1 f. 3 i. In three layers.
10. *Intermediate* 35 *f.*
Tenth bed 1 f.
11. *Intermediate* 28 *f.*
Eleventh bed 3 f. 3 i.
12. *Intermediate* 92 *f.*
Twelfth bed 1 f. 2 i.
13. *Intermediate* 21 *f.*
Thirteenth bed 1 f. 7 i. In three layers.
14. *Intermediate* 98 *f.*
Fourteenth bed 4 f. In two layers.
15. *Intermediate.*
Fifteenth vein 3 f. 3 i. In two layers.
16. *Intermediate* 56 *f.*
Sixteenth bed 3 f. In three layers.
17. *Intermediate* 42 *f.*
Seventeenth bed 3 f. In two layers.
18. *Intermediate* 91 *f.*
Eighteenth bed 1 f. 3 i. In two layers.
19. *Intermediate* 87 *f.*
Nineteenth bed 5 f. 6 i. In two layers.
20. *Intermediate* 42 *f.*
Twentieth bed 3 f. In two layers.
21. *Intermediate* 98 *f.*
Twenty-first bed 2 f. 3 i. In two layers.
22. *Intermediate* 49 *f.*
Twenty-second bed 4 f. In two layers.
23. *Intermediate* 28 *f.*
Twenty-third bed 1 f. 7 i. In three layers.
24. *Intermediate* 42 *f.*
Twenty-fourth bed 1 f. 2 i. In two layers.

43. *Intermediate* 49 *f.*
Forty-third bed 1 f. 7 i.
44. *Intermediate* 67 *f.*
Forty-fourth bed 3 f.
45. *Intermediate* 42 *f.*
Forty-fifth bed 2 f. In two layers.
46. *Intermediate* 21 *f.*
Forty-sixth bed 4 f. In two layers.
47. *Intermediate* 105 *f.*
Forty-seventh bed 2 f. In two layers.
48. *Intermediate* 70 *f.*
Forty-eighth bed 7 i.
49. *Intermediate* 7 *f.*
Forty-ninth bed 1 f. 3 i.
50. *Intermediate* 70 *f.*
Fiftieth bed 4½ i.
51. *Intermediate* 7 *f.*
Fifty-first bed 1 f. 3 i.
52. *Intermediate* 35 *f.*
Fifty-second bed 3 f. In two layers.
53. *Intermediate* 84 *f.*
Fifty-third bed 3 f. In two layers.
54. *Intermediate* 70 *f.*
Fifty-fourth bed 3 f. 3 i.
55. *Intermediate* 56 *f.*
Fifty-fifth bed 3 f. 3 i.
56. *Intermediate* 84 *f.*
Fifty-sixth bed 1 f. 7 i.
57. *Intermediate* 420 *f.*
Fifty-seventh bed 2 f. 7 i. In two layers.
58. *Intermediate* 105 *f.*
Fifty-eighth bed 1 f.
59. *Intermediate* 126 *f.*
Fifty-ninth bed 3 f. 3 i. In two layers.
60. *Intermediate* 154 *f.*
Sixtieth bed 1 f. 2 i.

that extent I observed strata of talcaceous, micaceous, and hornblende schistus, alternating with each other. We now walked to the town, which we found to be irregular and dirty.

"As the rocks upon the sea-shore near to this town are very interesting, we agreed to stay a day or two, and examine them particularly. I was the more anxious to do this, as they have long attracted the attention of mineralogists; but their particular geognostic characters have never been detailed in any publication. After having examined these rocks, the following is the result of the observations which I made.

"About a quarter of a mile from Portsoy, at the place to which I had traced the strata in coming into the town, the talcaceous schistus appeared in vertical strata; and nearly at the same place I observed a stratum of white marble, which is marked E, in the plan at the end of this volume. It is about twelve feet wide, and runs south-west and north-east, which is in the same direction with the bounding strata[*]. It appears to have been worked for ornamental purposes, as I observed several blocks upon the beach which seem to have been sawed. To this stratum succeeds a vertical stratum of micaceous schistus[†], marked F, which is compact, and of a blackish colour where in contact with the marble, but of a green colour where it is in contact with the next stratum, which is serpentine[‡]. The stratum of serpentine, marked G, which succeeds to the talcaceous schistus, is of great width, and, like the other strata, is nearly vertical, and runs in a

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"[*] This marble is white, or clouded with steel grey; but it is much mixed with scales of talc."

"[†] The talcaceous schistus, which alternates with these strata, has sometimes so much the appearance of compact micaceous schistus, that it cannot be distinguished from it: and as it approaches the marble, it is to be observed mixed with it, and passing into it."

"[‡] This serpentine is of various shades of olive and blackish green. Its fracture, which is either uneven, coarse splintery, or even fine splintery, presents canary-green scales. It is intermixed with various fossils, as asbestus, indurated steatites, talcite of Wallerius, calcareous spar, and iron pyrites."

blende rock, there are rugged cliffs of micaceous schistus, which is in some places alternated with quartz, and in others traversed by considerable granite veins. The micaceous schistus sometimes contains garnets; and the granite, which is great-grained, frequently contains crystals of schorl and mica, and sometimes it has the appearance that is called *pierre graphique*. Such appears to me the disposition and nature of the strata upon the shore at Portsoy[*].

“ As the geognostic characters of the serpentine at this place are interesting, I shall here mention, for the information of my readers, a few facts, which show that pretty nearly similar appearances have been observed in other countries. Zobtenberg, in Lower Silesia, consists entirely of serpentine, in which some hornblende is found, and its strata are nearly vertical[†]. In the Miner's Kalendar for 1790, Kohler informs us that serpentine and primitive limestone (marble) are nearly allied in their geognostic characters, and that sometimes they are disposed in strata which alternate. We are also informed that serpentine rests upon gneiss, and even alternates with it[‡], and also with quartzy talcaceous schistus[§].

“ The appearance of the veins of granite traversing hornblende rock and micaceous schistus, is by no means uncommon in Scotland; and in other countries similar appearances have been very often observed. The *pierre graphique* has been observed in Siberia to form the sides of veins where the topaz is found[||]; but at Sebritz it is disposed in beds with the common granite[¶]; and in the Uralian mountains Herman observed it mixed with the common granite[**]. Patrin, who found it in Siberia with the topaz, conjectures that it that an insulated block of stone, the organisation of which possessed a character so forcibly pronounced and so different to that of other rocks, might, if the spot where it was found were discovered, point out the distance it had traversed from its native place to that whither it was removed in the shape of a rounded block.

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[*] “ Some travellers are of opinion that the serpentine and marble form great veins, rather than vertical strata.”

[†] “ 4 Berl. Beobacht. 353.”

[‡] “ Charpentier Mineralogische Geographe von Churaclsichen Laude.”

[§] “ N. Nord. Beytrage. 149.”

[||] Jour. de Physique. Ann. 1791.

[¶] N. Bergmannishe's Journal, B. 2. 443.

[**] Herman Mineralogische Beschweibung des Uralaischen Giburges, B. 1. 144.

Messieurs de Sionville, Barral, Dolomieu, and other naturalists after them, made long and vain researches to discover the orbicular granite in its original situation. The search for it seemed to be abandoned, and specimens of the first block, dispersed in cabinets, became every day more and more rare; and when any pieces of it were exposed to sale, they obtained very considerable prices.

In the month of May 1809, that is to say, twenty-four years afterwards, M. Mathieu, a captain of artillery resident in Corsica, distinguished alike for his military talents and his taste for the study of nature, while traversing the steep granitic mountain by the side of the village of *Sainte Lucie*, seven leagues distant from the spot where the first block was found, observed attentively a saliant mass of rock, entirely covered with lichens and moss, which concealed its external character; but the interior texture of the stone being accidentally displayed by a break in it, M. Mathieu was agreeably surprised to find that the whole mass consisted of orbicular granite, similar in composition, colour, and mode of formation, to the orbicular granite which had so long and fruitlessly been sought: other masses, contiguous one to the other, and in a similar manner covered with lichens and old moss, occasioning a presumption that they might be of like nature, M. Mathieu tried them with his hammer, and discovered them to be actually the same species of orbicular granite. It was about three parts up the mountain, and on ground belonging to M. *Jean Paul Roccasserra*, that this discovery was made.

As the point the most essential to geology here is to ascertain distinctly the spot where this granite lies, that no doubt may be entertained of its adherence to the rock on which it lar granite, others are found of similar nature, more or less saliant, but the number of them is not great. M. Mathieu imagines them to be a species of kernels much more solid than the hornblende rock which gave them birth; and that this, not being of a composition equally hard, has been unable in an equal degree to resist the action of the weather, and consequently, becoming gradually decomposed in part, has left the orbicular granite bare.

The space occupied by these singular productions, at least such of them as are exposed to sight, including that filled by the hornblende rock, is about a hundred yards; after which the ordinary granite reappears.

M. Mathieu, not content with simply affording me instructive information respecting the discovery he had made, was so kind and liberal as to enrich my collection with a series of beautiful specimens of all the varieties of orbicular granite he had collected on the mountain of Sainte Lucie.

I here annex a short description of those which appeared to me the most interesting.

No. 1. A specimen, the thickness of which is one inch and three lines, diameter four inches, of orbicular granite, resembling as well in composition, shade of colour, and hardness, as in the form of its globules, that of *Taravo*, possessing also like that some small brilliant points of a substance apparently metallic, and of a silvery white colour, which affects the magnet, and belongs to the class of magnetic pyrites. This substance takes a beautiful polish; grains of this description are not numerous, but distinctly sprinkled in the mass, as well as in the globules themselves of this granite. In every respect, in short, it seems a similar species to that of the valley of *Taravo;* but M. Mathieu informed me that this beautiful variety is not frequent: it exists, however, in its original site, which suffices.

No 2. Orbicular granite, the composition of which is the same with that of the granite of the plain of *Taravo*, but ceding, is lively; what indeed renders this specimen still more pleasing, the globules, being tinged with an extremely light but evident shade of black, have acquired by the mixture a bluish appearance, highly grateful to the eye.

No. 5. Finally, one of the most remarkable varieties of the orbicular granite discovered by M. Mathieu, and at the same time the most clearly distinct as a variety, is that which, on nearly a black and equal ground, resulting from a uniform mixture of white felspar and black hornblende in particles, is distinguished by its globules having in general the first circle white. As black is the dominant colour in this singular variety of orbicular granite, the white circles which succeed, and are alternated with black, participate of this tint, and are, as it were, veiled with black: they are, however, very distinct, owing to their contrasting with the other circles, which are of the deepest black. This variety, which takes a polish equally beautiful with the other specimens, and is equally hard, is found in tolerably large masses. It is admirably adapted for urns, and other vases of a grave aspect.

Such are the principal varieties of the orbicular granite, for the discovery of which we are indebted to M. Mathieu. I have thought right to give these details at length, the better to delineate a rock of which nature has been so little prodigal. I reserve all the facts, that I may resume them when, if I am able, I may occupy myself with the theory of this stone; for if it be clearly demonstrated, as every thing seems to show, that this is the native site from which the block of *Taravo* was torn, an exact *datum* will be afforded of a very singular geological fact.

GLOBULAR PORPHYRY OF CORSICA;

Its disposition in large veins.

It was reserved for M. Mathieu to find on its natal spot, mountains of granite in search of orbicular granite, in which search he was unsuccessful, he had in some measure been indemnified by the discovery, on the flank of a mountain covered with wood, between Monte Pertusato and the valley which leads to Santa Maria la Stella, of "a block of stone, four feet and a half in length by three in breadth, which was sunk in the earth, and displayed on one of its sides globular bodies remarkable for their disposition and colour."* M. Rampasse added, that he was unable to sunder more than about eighty pounds weight from the stone, and that he considered it a proper appendage to the orbicular granite. Some time after M. Rampasse came to Paris, and the specimens of globular porphyry which he brought with him strongly excited the attention of naturalists.

It was not then generally known, and I myself was at that time ignorant, that M. Mathieu had discovered, twelve months before, orbicular porphyry on its native site, not only in large masses, but in a kind of veins, very thick and of considerable extent, and that he had already sent to Paris two memoirs on the occasion, accompanied by plans and charts, the one intended for presentation to the Institute of France, the other addressed to M. Vialart-Saint-Morys, who resides on one of his estates at Houdamville, in the neighbourhood of Clermont, in the department of the Oise; this latter was also accompanied by several specimens of the stone, which, with the memoir, were contained in a case that had not yet been opened, and which M. de Saint Morys was requested by M. Mathieu, on his passing through Paris, to deliver into my hands. From this memoir I propose to designate the site of the globular porphyry found by M. Mathieu, in a different spot from that in which M. Rampasse discovered his insulated block partly buried in the earth.

"The territory on which the globular porphyry is found," says M. Mathieu, in a memoir sent to M. Vialart-Saint-Morys,

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* See the letter of M. Rampasse, inserted *Tome viii. page* 470, of the *Annales du Museum d'Histoire Naturelle*.

Bocca Galeria the felspar, harder and of a deeper colour than any where else, contains globules of a paler hue; there also are found most beautiful geods of a substance much more indurated, which seem as if agatised, and are of a reddish brown colour; at *Fornaci* the same kind of geods, but of a violet tint: these last are very bulky, some of them being more than a foot and a half in diameter.

"At *Elbo*, on the sea-shore, globules are found detached from their matrices, forming a sort of insulated balls. It appears that the action of the waves has been sufficiently forcible to beat down, break, and wear away, blocks of the porphyry; but that the globules being much more hard, have more strongly resisted degradation, and been cast on shore.

"To conclude: this vast extent is entirely composed of porphyrous rocks, intersected by numerous veins in the form of walls, in which the globular system is every where manifested; and this wide field for observation well deserves the attention of skilful mineralogists, who could not fail of making numerous discoveries."

It now remains I should give a detail of the different specimens of orbicular porphyry, presented to me by M. Mathieu.

No. 1. Porphyry of an isabella colour, with a very light shade of the rose, the globules spherical, very small and radiant, some of them encircled by a distinct line, others without this distinct line, and united with the ground in such manner as to seem to form but one body with their matrix. The ground, which is felspar, very compact, and formed of extremely small particles, receives an excellent polish, for it is hard, but susceptible at the same time of decomposition, as well from the oxydation of the iron it contains, as from other causes. The largest globules of this porphyry are but four lines in diameter, the smallest in general three. When this stone is broken for the purpose of obtaining specimens, the globules sometimes separate in a perfect state, and leave the mark of their position in the stone.

a fact that the spots and the lineaments of a blackish tint are harder in a certain degree than those which are red; this is most evident after the stone has been submitted to a polish, and is exposed to a favourable light. The black parts are then seen to be slightly saliant, and to exhibit, notwithstanding the whole stone receives a beautiful polish, a glossiness more lively and more brilliant than the rest of it.

The globules enclosed in this porphyry are of a flesh colour varying in shade, with radii diverging from the centre to the circumference, traced by lines of a more evident colour than the rest of the globule, and rather blackish; these lines irradiate from a kernel in the centre, of a uniform but more red colour than the rest of the globule. A broad circular line, almost white, or but faintly tinged with red, surrounds each globule, and determines the circumference. But, in order to obtain all these results in the best manner, on sawing the specimens care should be taken to divide each ball as nearly as possible in the centre, so that the kernel may appear: the balls thus cut take an exquisite polish, which exhibits in a plain manner the effect of this singular system of globular crystallisation.

No. 3. A perfectly spherical ball, accidentally separated from the rock; it is three inches and six lines in diameter; a circle five lines broad, and uniform in its breadth, surrounds the exterior of the ball, which is composed of a kind of hard felspar, analogous to that of the matrix, but of which the points, of a reddish colour, are very small. All these present imperfect crystallisations in small compact divergent rays.

A second circle, two lines and a half in breadth, of compact felspar of a fawn-coloured white, is enclosed within the external circle, and the rest of the ball is only an assemblage of crystals of compact felspar of a somewhat deeper tint, which direct to a common centre: I had this separated ball cut into two equal parts.

No. 4. In a beautiful specimen composed of three large

No. VII. *Reineggs on the Mineralogy of the Archipelago.*

[Scelta di opuscoli interessanti. Milan 1777, 8vo. vol. xxxii.*]

The mountains of Istria are connected with those of Carniola and Stiria, of a moderate height, but rather precipitous. They entirely consist of limestone, with a prodigious quantity of nummulites. Statues have been formed of it, in which the shells produce the effect of marks of the small-pox. The strata are strangely varied, sometimes horizontal, sometimes vertical. They are mostly clothed with olives and vines.

Further on is formed a siliceous sandstone, which afterwards changes for white limestone, which continues to the neighbourhood of Ragusa.

The mountains of Dalmatia are of the same kind, being mostly composed of a compact limestone, capable of polish.

Near Cattaro appears a kind of gneiss among the fissures of the limestone. Towards Scutari the mountains are granite. The Pasha presented to him some medals of iron, which he says may be as ancient as the time of Lycurgus †.

The chain of mountains of Epirus continues into Arcadia, where the summits are very high.

Most of the isles, as Cefalonia for example, have a high mountain in the middle, which gradually lowers towards the sea. Mylo presents warm sulphureous waters. Some of the hills of this isle are calcareous, others of a brown marly clay. There is also found a fine talcaceous earth. The subterranean fires, mentioned by Tournefort, no longer exist; but there are vestiges of volcanoes towards the north, where the hills are granitic, with basalt and vitrifications. There is a hill territory of Smyrna, presents many ancient columns of basalt and granite; but in the mosques the Turks, from superstition, colour them green or red. About five miles* from Smyrna is a place called Nemphis, where there are mines of lead which yield silver, the hills being traversed by veins of gneiss.

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* This paper being short, and little known, it was thought proper to preserve it here.

† This is truly singular, as such medals have always formed a desideratum in cabinets, and we can hardly suspect a mineralogist of mistaking the metal.

No. VIII. *Account of some Rocks in the south of Hindostan*†.

"In ascending the Ghats, I had an excellent opportunity of observing the strata, where the rock had been cut away to form the road. The grand component part of these mountains is a granite, consisting of white felspar and quartz, with dark green mica in a small proportion to the other two ingredients. The particles are angular, and of moderate size. It seems to come near to the granitello of the Italians (Waller. Min. ii. p. 423), and is an excellent material for building, as it is readily cleft by wedges, and is at the same time strong and durable. Intermixed with this is another stone, in a state of decay, consisting of angular masses of various sizes, divided by fissures, so as to be separable with little difficulty. The sides of the fissures are tarnished, and covered by extraneous matter. This is a stone commonly called a granite in decay, the mica being supposed to have been entirely decomposed, and the felspar to be in the act of decomposition, and to have assumed an arid powdery appearance, while the glassy quartz retains its natural consistence. That the strata in question are in a state of decay, from the numerous fissures in them, I have no doubt; but there are other strata of similar component parts common all over the lower *Carnatic*, especially at *Mahabalipura* (the seven Pagodas), which are in the most perfect state of preservation, without the smallest

---

* German miles?

† From Buchanan's Travels, 3 vols. 4to.

"The stones that are employed in building the temples at *Magadi* are:

"1. The granitic porphyry, or the granite which contains large masses of red felspar in a small-grained mixture of grey quartz and black mica, which I described at *Ráma-giri*. Near *Savanadurga* there is an excellent quarry of this stone.

"2. A granite, consisting chiefly of black mica and red felspar. This may be procured of a very large size.

"3. The common grey granite of the country.

"I met also with the two following stones:

"1. A granite with large grains, black and white. This may be procured of great size.

"2. A most ornamental aggregated rock. The basis is green, of what nature I am uncertain; perhaps it may be a hornstone. It contains veins of white quartz, and concretions of red felspar. The whole takes an elegant polish, and may, in Mr. Kirwan's acceptation of the word, be considered as a porphyry. Near the surface the rock is full of rents; but by digging deep, it is said large masses may be procured. It seems to differ from the fine green stone which was found in the palace at Seringapatam, only by containing felspar." *

Quarry of black stone.

"This quarry is situated about half a mile east from the village †, and rises in a small ridge about half a mile long, 100 yards wide, and from 20 to 50 feet in perpendicular height. This ridge runs nearly north and south, in the common direction of the strata of the country, and is surrounded on all sides by the common grey granite, which, as usual, is penetrated in all directions by veins of quartz and felspar; but neither of these enter the quarry.

"This stone is called *Caricullu*, or black stone, by the natives, who give the same appellation to the quartz impregnated with iron, and to the brown hematites; and in fact decaying state; and some of them are entirely penetrated with long slender needles of schorlaceous actinote." *

---

* Vol. i. p. 182.

† Cada-hully.

The hill on which Mail-Cotay stands consists of a kind of gneiss, but the description is very confused: also a granitel of black hornblende slate, mixed with white quartz in such a manner that when broken longitudinally the quartz forms veins, when transversely spots. †

"The strata on the Ghats are much covered with the soil, so that it is in a few places only that they are to be seen. Having no compass, I could not ascertain their course; but far as I could judge from the sun in a country so hilly, they appeared to run north and south, with a dip to the east of about 30 degrees. Wherever it appears on the surface, the rock, although extremely hard or tough, is in a state of decay; and owing to this decay, its stratified nature is very evident. The plates, indeed, of which the strata consist, are in general under a foot in thickness, and are subdivided into rhomboidal fragments by fissures which have a smooth surface. It is properly an aggregate stone, composed of quartz impregnated with hornblende. From this last it acquires its great toughness. In decay, the hornblende in some plates seems to waste faster than in others, and thus leaves the stone divided into zones, which are alternately porous and white. I am inclined to think that all mountains of a hornblende nature are less rugged than those of granite, owing to their being more easily decomposed by the action of the air. This rock contains many small crystallised particles, apparently of iron." ‡

---

* Vol. ii. p. 62.

† Vol. ii. p. 78.

‡ Vol. iii. p. 205.

No. X. *Explanation of the direction and inclination of Veins.*

[See the Plate.]

The position of metallic veins is ascertained and described by three different angles; that of the *direction*, *dip*, and *inclination*.

The angle of direction, or simply the direction, is ascertained by observing the point of the compass, or degree of the horizon, it tends towards, as *A B*, Fig. 1.

The dip is the angle which it makes with the plane of the horizon, as *B A E*, Fig. 2.

The inclination is the angle which one of its sides makes with a vertical plane, as *a b c*, Fig. 3; where *b c* represents the transverse section of the vein, and *a b* that of the vertical plane.

This is further illustrated by Fig. 4; where *A B* represents the perspective view of a metallic vein. *C D* is the compass placed parallel to the horizon, and *E F* is the direction of the vein.

The angle *F E B* is the dip, being the angle which the vein makes with the horizontal plane; and the angle *a b c* is the inclination, or the angle which the side of the vein makes with the vertical plane *a b*.

DOM. V. IRON.
VI. TIN.
VII. LEAD.
VIII. MERCURY.
IX. ZINC.
X. ANTIMONY.
XI. ARSENIC.
XII. BISMUTH.
XIII. COBALT.
XIV. NICKEL.
XV. MANGANESE.
XVI. MOLYBDENA.
XVII. TITAN[*].
XVIII. CHROME.
XIX. SCHEELE.
XX. URANIUM, &c.&c.

Dr. Thomson observes that all metals are found in the following states: 1. Metallic, either alone or combined. 2. Combined with sulphur. 3. Oxyds, that is, united with oxygen. 4. Combined with acids. Each order therefore, as he adds, may be divided into the four following Genera.

1. Alloys.	3. Oxyds.
2. Sulphurets.	4. Salts.

But Haüy has, on the contrary, considered each metal as a genus; and Werner, an excellent judge of metallogy in particular, considers each metal as a genus, and the various combinations as species.

But as Mode chiefly implies the mode of chemical combination, it is evident that these pretended genera and species, which are wholly vague as being derived from an analogy merely imaginary between inert and animated nature, are most properly and peculiarly Modes. The Aspects are equally applicable as in Petralogy and Lithology. The Structure is also applicable to the composition in general; as in *structura verborum* it is classically applied to very small objects[*].

METALLOGY.

DOMAIN I.

GOLD.

NOME I. ALLOYS.

Mode I. Pure, or rather entire, for it always contains silver or copper.

Structure I. Massive.

Diversities, 1. in rocks; 2. in *pepitos*, or detached masses found in clay or sand, &c.

Structure II. Disseminated in rocks, sands, &c.

Structure III. Crystallised.

Aspect 1. In cubes, or other regular forms.

Aspect 2. Dendritic, like branches, leaves, &c.

Structure IV. Earthy, of a brownish red, like Spanish snuff.

Mode II. Electrum, or greatly alloyed with silver.

Structure I. Compact.
Dendritic.

Mode III. Alloyed with antimony.

Mode IV. Alloyed with the Sylvanite of Kirwan, so called from Transylvania, where it is found; the Tellurium of Klaproth: but Kirwan's appellation is received by Werner.

---

[*] Another name would be preferable. In the Greek *titan* is *lime*.

[*] See Linn. p 14 (as already quoted), where he says the natural knowledge of stones arises from their structure, the chemical from analysis.

MODE XV. Arseniate of Iron.

STRUCTURE I. Crystallised.
II. With Copper.

MODE XVI. Green Iron Earth.

Aspect 1. Friable.
2. Coherent.

This may be compared with the Petralogy, in regard to the Structures and Aspects. The genera of Thomson have not been admitted by other writers, who arrange all the species in succession, without dividing them into genera. But as these large divisions of Thomson seem very useful, they might be retained under the name of Nomes, or subsidiary districts.

In Lithology Dr. Thomson not having admitted Orders or Genera, but only Families and Species, no confusion could arise; and the Modes belong to the mixtures of the same substance, as Strontian is one Mode, and Celestine is another; that is, the Species of Werner become Modes, while his Subspecies become Structures.

In like manner if we take Iron the first Species, Native Iron is a Mode, or special chemical combination. The second Species, Iron Pyrites, is another Mode with four Structures, Compact, Radiated, Cellular, and Capillary; the Hepatic being an Aspect. The fourth Species, Magnetic Iron-stone, is also a chemical Mode of great importance; whereas in following Dr. Thomson's arrangement it is merely a Structure, while there is not only nothing particular in its exterior Structure, but its Aspects, the Compact, Laminar, and Crystallised, are real Structures. The fifth Species is Specular Iron Ore, which becoming a Structure instead of a Mode, the terms Massive and Crystallised, which belong to Structure, become mere Diversities. In the others, Amorphous, Crystallised, Compact, Columnar, Pisiform, Earthy, become Aspects instead of Structures.

It is therefore necessary in the Metals, as in the Earths, that each new Species or different combination, for example, with Carbon, Arsenic, &c. or with different modifications of various Earths, should be called a Mode, as in the other provinces that word supplies the term Species, and implies in itself a new mode of chemical combination; and in this way only can the term Structure revert to its original destination.

The classical word Nome, derived from Egypt, the parent country of Chemistry, may be found very appropriate, as already explained.

The dignity and importance of the Metals also require a multiplication, instead of a diminution, of the higher terms in the nomenclature. Nor must it be forgotten that the very nature of the subject, in which the substances and their qualities are of themselves various and vague, would render any attempt at mathematical precision rather pedantic than useful or distinct (the qualities, like the substances themselves, often passing into each other); and that every system, even the Newtonian, has its anomalies.

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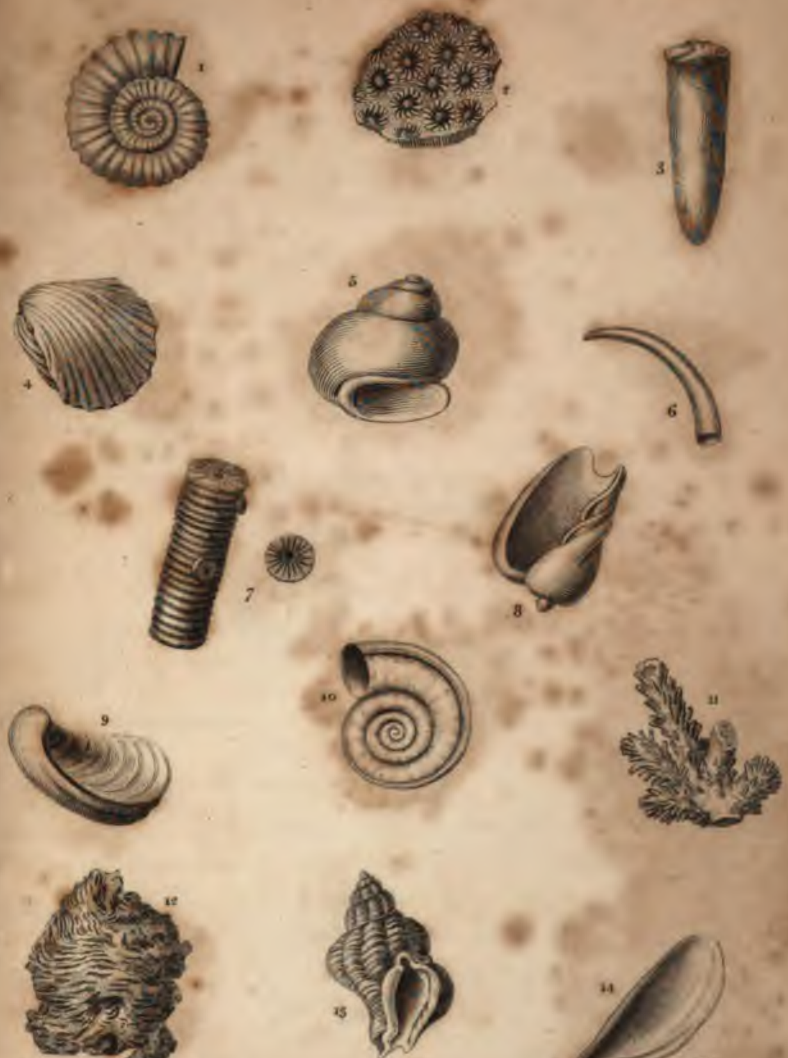
PLATE I



1. Ammonite
2. Astroite
3. Belemnite
4. Chamite
5. Cochlite
6. Dentalite
7. Entrochite
8. Globosite
9. Gryphite
10. Helicite
11. Madreporite
12. Meandrite
13. Muricite
14. Musculite

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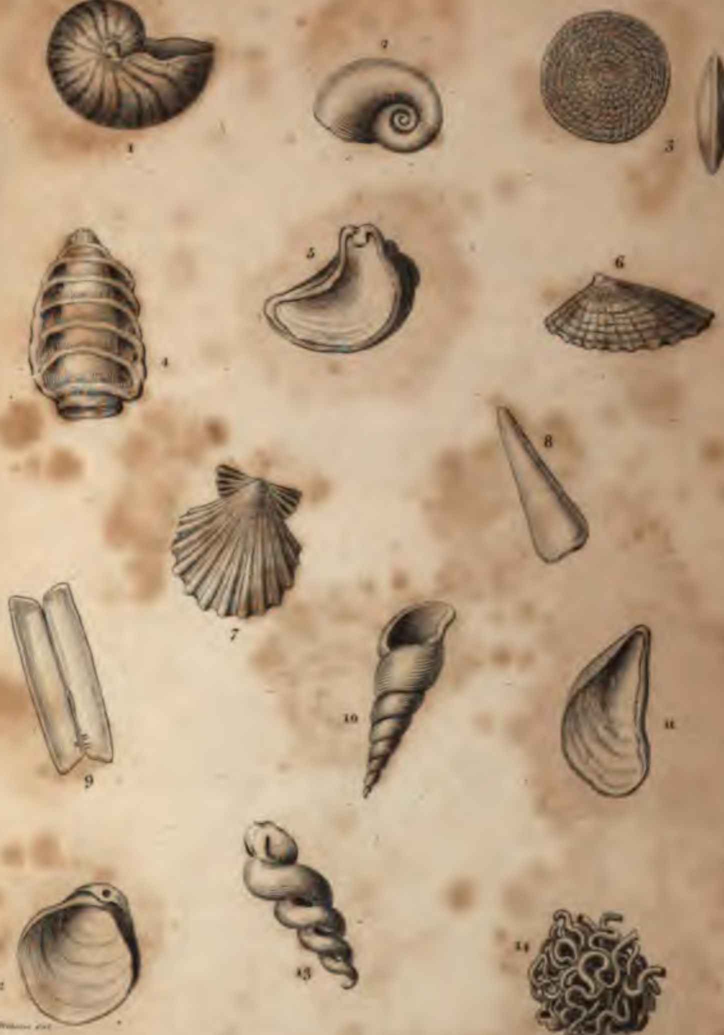
PLATE II



1. Nautilite
2. Nerite
3. Nummulite
4. Orthoceratite
5. Ostracite
6. Patellite
7. Pectinite
8. Pinnite
9. Solenite
10. Strombite
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